PRODUCT MANUAL

RabbitCore RCM3400

C-Programmable Analog Core Module
with 10/100Base-T Reference Design

User's Manual

019–0122_N

RabbitCore RCM3400 User's Manual

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TABLE OF CONTENTS

Chapter 1. Introduction 1

1.1 RCM3400 Features 1
1.2 Advantages of the RCM3400 3
1.3 Development and Evaluation Tools 4
1.3.1 RCM3400 Development Kit 4
1.3.2 Software 5
1.3.3 Connectivity Interface Kits 5
1.3.4 Online Documentation 5

Chapter 2. Getting Started 7

2.1 Install Dynamic C 7
2.2 Hardware Connections 8
2.2.1 Attach Module to Prototyping Board 8
2.2.2 Connect Programming Cable 9
2.2.3 Connect Power 10
2.2.3.1 Overseas Development Kits 10
2.3 Run a Sample Program 11
2.3.1 Troubleshooting 11
2.4 Where Do I Go From Here? 12
2.4.1 Technical Support 12

Chapter 3. Running Sample Programs 13

3.1 Introduction 13
3.2 Sample Programs 14
3.2.1 Serial Communication 15
3.2.2 A/D Converter Inputs 17
3.2.3 Real-Time Clock 18
3.2.4 TCP/IP Sample Programs 18
3.2.5 LCD/Keypad Module Sample Programs 18

Chapter 4. Hardware Reference 19

4.1 RCM3400 Digital Inputs and Outputs 20
4.1.1 Memory I/O Interface 26
4.1.2 Other Inputs and Outputs 26
4.2 Serial Communication 27
4.2.1 Serial Ports 27
4.2.2 Programming Port 27
4.3 Serial Programming Cable 29
4.3.1 Changing Between Program Mode and Run Mode 29
4.3.2 Standalone Operation of the RCM3400 30

4.4 A/D Converter 31
4.4.1 A/D Converter Calibration 33
4.4.2 A/D Converter Power Supply 33
4.5 Other Hardware 34
4.5.1 Clock Doubler 34
4.5.2 Spectrum Spreader 34
4.6 Memory 35
4.6.1 SRAM 35
4.6.2 Flash EPROM 35
4.6.3 Dynamic C BIOS Source Files 35

Chapter 5. Software Reference 37
5.1 More About Dynamic C 37
5.2 Dynamic C Function Calls 39
5.2.1 Digital I/O 39
5.2.2 Serial Communication Drivers 39
5.2.3 TCP/IP Drivers 39
5.2.4 Prototyping Board Function Calls 40
5.2.5 Board Initialization 40
5.2.6 Analog Inputs 41
5.3 Upgrading Dynamic C 55
5.3.1 Upgrades 55

Appendix A. RCM3400 Specifications 57
A.1 Electrical and Mechanical Characteristics 58
A.1.1 Headers 62
A.2 Bus Loading 63
A.3 Rabbit 3000 DC Characteristics 66
A.4 I/O Buffer Sourcing and Sinking Limit 67
A.5 Conformal Coating 68
A.6 Jumper Configurations 69

Appendix B. Prototyping Board 71
B.1 Introduction 72
B.1.1 Prototyping Board Features 73
B.2 Mechanical Dimensions and Layout 75
B.3 Power Supply 76
B.4 Using the Prototyping Board 77
B.4.1 Adding Other Components 79
B.4.2 Measuring Current Draw 79
B.4.3 Analog Features 80
B.4.3.1 A/D Converter Inputs 80
B.4.3.2 Thermistor Input 82
B.4.3.3 A/D Converter Calibration 83
B.4.4 Serial Communication 84
B.4.4.1 RS-232 85
B.4.4.2 RS-485 86
B.4.4.3 Ethernet Port 88
B.4.5 Other Prototyping Board Modules 89
B.5 RCM3400 Prototyping Board Jumper Configurations 90

Appendix C. Using the TCP/IP Features 93
C.1 TCP/IP Connections 93
C.2 TCP/IP Primer on IP Addresses 95
C.2.1 IP Addresses Explained 97
C.2.2 How IP Addresses are Used 98
C.2.3 Dynamically Assigned Internet Addresses 99

C.3 Placing Your Device on the Network 100
C.4 Running TCP/IP Sample Programs 101
C.4.1 How to Set IP Addresses in the Sample Programs 102
C.4.2 How to Set Up your Computer's IP Address for Direct Connect 103
C.5 Run the PINGME.C Sample Program 104
C.6 Running Additional Sample Programs With Direct Connect 104
C.7 Where Do I Go From Here? 105

Appendix D. LCD/Keypad Module 107

D.1 Specifications 107
D.2 Contrast Adjustments for All Boards 109
D.3 Keypad Labeling 110
D.4 Header Pinouts 111
D.4.1 I/O Address Assignments 111
D.5 Mounting LCD/Keypad Module on the Prototyping Board 112
D.6 Bezel-Mount Installation 113
D.6.1 Connect the LCD/Keypad Module to Your Prototyping Board 115
D.7 Sample Programs 116
D.8 LCD/Keypad Module Function Calls 117
D.8.1 LCD/Keypad Module Initialization 117
D.8.2 LEDs 117
D.8.3 LCD Display 118
D.8.4 Keypad 138

Appendix E. Power Supply 141

E.1 Power Supplies 141
E.1.1 Battery-Backup Circuits 141
E.1.2 Reset Generator 142

Index 143

1. INTRODUCTION

The RCM3400 is a compact module that incorporates the powerful Rabbit® 3000 microprocessor, flash memory, static RAM, digital I/O ports, analog inputs, and PWM outputs.

The Development Kit has the essentials that you need to design your own microprocessor-based system, and includes a complete Dynamic C software development system. This Development Kit also contains a Prototyping Board that will allow you to evaluate the RCM3400 and to prototype circuits that interface to the RCM3400 module. You will also be able to write and test software for the RCM3400 modules, including Ethernet or TCP/IP applications.

Throughout this manual, the term RCM3400 refers to the complete series of RCM3400 RabbitCore modules unless other production models are referred to specifically.

The RCM3400 has a Rabbit 3000 microprocessor operating at up to 29.4 MHz, static RAM, flash memory, an 8-channel A/D converter, two clocks (main oscillator and timekeeping), and the circuitry necessary for reset and management of battery backup of the Rabbit 3000's internal real-time clock and the static RAM. Two 34-pin headers bring out the Rabbit 3000 I/O bus lines, parallel ports, A/D converter channels, and serial ports.

The RCM3400 receives its +3.3 V power from the customer-supplied motherboard on which it is mounted. The RCM3400 can interface with all kinds of CMOS-compatible digital devices through the motherboard.

1.1 RCM3400 Features

- Small size: 1.16" × 1.37" × 0.31"
  (29 mm × 34 mm × 8 mm)
- Microprocessor: Rabbit 3000 running at up to 29.4 MHz
- 47 parallel 5 V tolerant I/O lines: 41 configurable for I/O, 3 fixed inputs, 3 fixed outputs
- Two additional digital inputs, one additional digital output
- Combinations of up to eight single-ended or four differential analog inputs

- One additional analog input (CONVERT)
- External reset input
- Alternate I/O bus can be configured for 8 data lines and 6 address lines (shared with parallel I/O lines), I/O read/write
- Ten 8-bit timers (six cascadable) and one 10-bit timer with two match registers
- 512K flash memory, 512K SRAM, (options for 256K flash memory and 256K SRAM)
- Real-time clock
- Watchdog supervisor
- Provision for customer-supplied backup battery via connections on header J2
- 10-bit free-running PWM counter and four width registers
- Two-channel Input Capture can be used to time input signals from various port pins
- Two-channel Quadrature Decoder accepts inputs from external incremental encoder modules
- Five CMOS-compatible serial ports: maximum asynchronous baud rate of 5.5 Mbps. Four ports are configurable as a clocked serial port (SPI), and two ports are configurable as SDLC/HDLC serial ports.
- Supports 1.15 Mbps IrDA transceiver

There are two RCM3400 production models. Table 1 summarizes their main features.

Table 1. RCM3400 Features

Feature	RCM3400	RCM3410
Microprocessor	Rabbit 3000 at 29.4 MHz	
Flash Memory	512K	256K
SRAM	512K	256K
A/D Converter	12 bits	
Serial Ports	5 shared high-speed, CMOS-compatible ports: 5 are configurable as asynchronous serial ports; 4 are configurable as clocked serial ports (SPI); 2 are configurable as SDLC/HDLC serial ports; 1 asynchronous serial port is used during programming	

The RCM3400 can be programmed through connections on the motherboard supporting RS-232, USB with an RS-232/USB converter, or over an Ethernet connection.

Appendix A provides detailed specifications for the RCM3400.

1.2 Advantages of the RCM3400

- Fast time to market using a fully engineered, “ready-to-run/ready-to-program” microprocessor core.
- Competitive pricing when compared with the alternative of purchasing and assembling individual components.
- Easy C-language program development and debugging
- Rabbit Field Utility to download compiled Dynamic C .bin files, and cloning board options for rapid production loading of programs.
- Generous memory size allows large programs with tens of thousands of lines of code, and substantial data storage.
- Reference design allows integrated Ethernet port for network connectivity, with royalty-free TCP/IP software.

1.3 Development and Evaluation Tools

1.3.1 RCM3400 Development Kit

The RCM3400 Development Kit contains the hardware essentials you will need to use your RCM3400 module. The items in the Development Kit and their use are as follows.

- RCM3400 module.
- Prototyping Board.
- AC adapter, 12 V DC, 1 A. (Included only with Development Kits sold for the North American market. A header plug leading to bare leads is provided to allow overseas users to connect their own power supply with a DC output of 8–24 V at 8 W.)
- 10-pin header to DB9 programming cable with integrated level-matching circuitry.
- ***Dynamic C*** CD-ROM, with complete product documentation on disk.
- ***Getting Started*** instructions.
- A bag of accessory parts for use on the Prototyping Board.
- ***Rabbit 3000 Processor Easy Reference*** poster.
- Registration card.

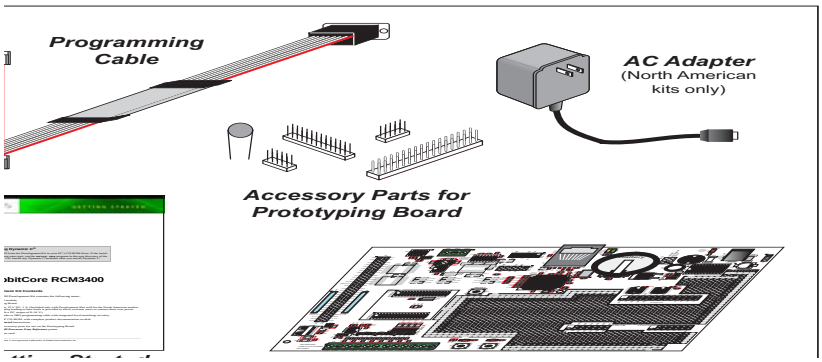


Figure 1. RCM3400 Development Kit

1.3.2 Software

The RCM3400 is programmed using version 7.32 or later of Dynamic C. A compatible version is included on the Development Kit CD-ROM.

Digi also offers add-on Dynamic C modules containing the popular μC/OS-II real-time operating system, as well as PPP, Advanced Encryption Standard (AES), and other select libraries. In addition to the Web-based technical support included at no extra charge, a one-year telephone-based technical support module is also available for purchase. Visit our Web site at www.digi.com or contact your Digi sales representative or authorized distributor for further information.

1.3.3 Connectivity Interface Kits

Digi has available additional interface kits to allow you to provide a wireless interface to the RCM3400 and to use the RCM3400 with header sockets that have a 0.1" pitch.

- 802.11b Wi-Fi Add-On Kit (Part No. 101-0998)—The Wi-Fi Add-On Kit for the RCM3400 footprint consists of an RCM3400 Interposer Board, a Wi-Fi CompactFlash card with a CompactFlash Wi-Fi Board, a ribbon interconnecting cable, and the software drivers and sample programs to help you enable your RCM3400 module with Wi-Fi capabilities. The RCM3400 Interposer Board is placed between the RCM3400 module and the RCM3400 Prototyping Board so that the CompactFlash Wi-Fi Board, which holds the Wi-Fi CompactFlash card, can be connected to the RCM3400-based system via the ribbon cable provided.
- Connector Adapter Board (Part No. 151-0114)—allows you to plug the RCM3400 whose headers have a 1.27 mm pitch into header sockets with a 0.1" pitch.

Visit our Web site at www.digi.com or contact your Digi sales representative or authorized distributor for further information.

1.3.4 Online Documentation

The online documentation is installed along with Dynamic C, and an icon for the documentation menu is placed on the workstation's desktop. Double-click this icon to reach the menu. If the icon is missing, use your browser to find and load **default.htm** in the **docs** folder, found in the Dynamic C installation folder.

The latest versions of all documents are always available for free, unregistered download from our Web sites as well.

2. GETTING STARTED

This chapter describes the RCM3400 hardware in more detail, and explains how to set up and use the accompanying Prototyping Board.

NOTE: This chapter (and this manual) assume that you have the RCM3400 Development Kit. If you purchased an RCM3400 module by itself, you will have to adapt the information in this chapter and elsewhere to your test and development setup.

2.1 Install Dynamic C

To develop and debug programs for the RCM3400 (and for all other Rabbit Semiconductor hardware), you must install and use Dynamic C.

If you have not yet installed Dynamic C version 7.32 (or a later version), do so now by inserting the Dynamic C CD from the RCM3400 Development Kit in your PC's CD-ROM drive. If autorun is enabled, the CD installation will begin automatically.

If autorun is disabled or the installation does not start, use the Windows **Start | Run** menu or Windows Disk Explorer to launch **`setup.exe`** from the root folder of the CD-ROM.

The installation program will guide you through the installation process. Most steps of the process are self-explanatory.

Dynamic C uses a COM (serial) port to communicate with the target development system. The installation allows you to choose the COM port that will be used. The default selection is COM1. You may select any available port for Dynamic C's use. If you are not certain which port is available, select COM1. This selection can be changed later within Dynamic C.

NOTE: The installation utility does not check the selected COM port in any way. Specifying a port in use by another device (mouse, modem, etc.) may lead to a message such as **`"could not open serial port"`** when Dynamic C is started.

Once your installation is complete, you will have up to three new icons on your PC desktop. One icon is for Dynamic C, one opens the documentation menu, and the third is for the Rabbit Field Utility, a tool used to download precompiled software to a target system.

If you have purchased any of the optional Dynamic C modules, install them after installing Dynamic C. The modules may be installed in any order. You must install the modules in the same directory where Dynamic C was installed.

2.2 Hardware Connections

2.2.1 Attach Module to Prototyping Board

Turn the RCM3400 module so that the Rabbit 3000 chip is facing up and the Rabbit logo is facing the direction shown in Figure 2 below. Align the pins from headers J1 and J2 on the bottom side of the module into header sockets RCM1JA and RCM1JB on the Prototyping Board. The shaded corner notch at the top left corner of the RCM3400 module should face the same direction as the corresponding notch below it on the Prototyping Board.

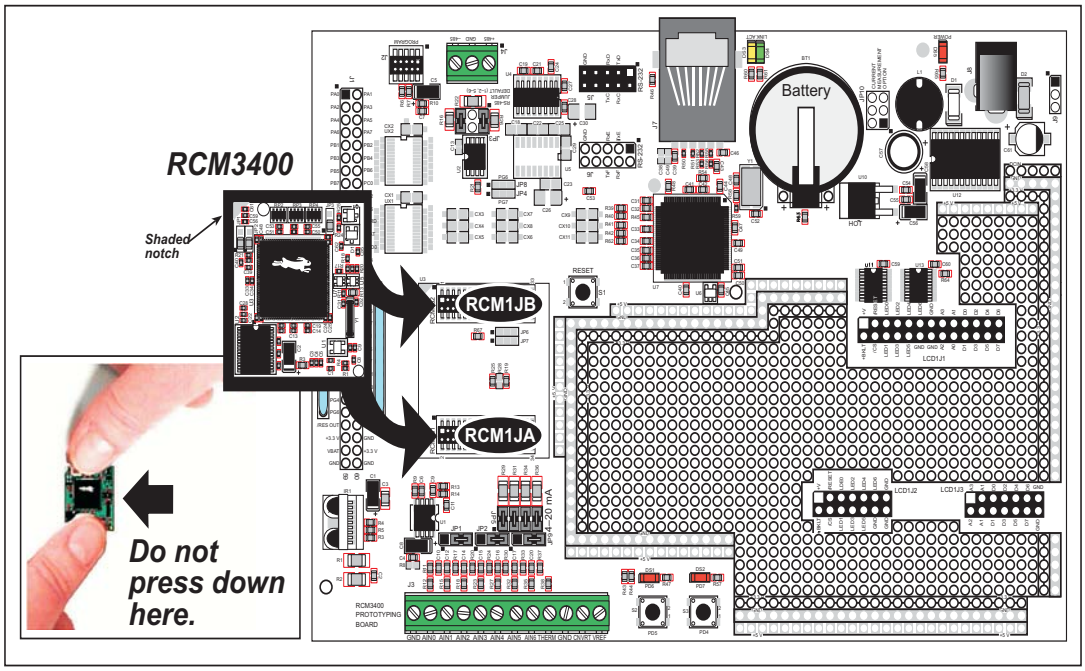


Figure 2. Install the RCM3400 Module on the Prototyping Board

NOTE: It is important that you line up the pins on headers J1 and J2 of the RCM3400 module exactly with the corresponding pins of header sockets RCM1JA and RCM1JB on the Prototyping Board. The header pins may become bent or damaged if the pin alignment is offset, and the module will not work. Permanent electrical damage to the module may also result if a misaligned module is powered up.

Press the module's pins firmly into the Prototyping Board header sockets—press down in the area above the header pins using your thumbs or fingers over the connectors as shown in Figure 2. Do ***not*** press down on the middle of the RCM3400 module to avoid flexing the module, which could damage the module or the components on the module.

Should you need to remove the RCM3400 module, grasp it with your fingers along the top and bottom by the connectors and gently work the module up to pull the pins away from the sockets where they are installed. Do ***not*** remove the module by grasping it at the sides.

2.2.2 Connect Programming Cable

The programming cable connects the RCM3400 to the PC running Dynamic C to download programs and to monitor the RCM3400 module during debugging.

Connect the 10-pin connector of the programming cable labeled **PROG** to header J2 on the RCM3400 Prototyping Board as shown in Figure 3. Be sure to orient the marked (usually red) edge of the cable towards pin 1 of the connector. (Do not use the **DIAG** connector, which is used for a normal serial connection.)

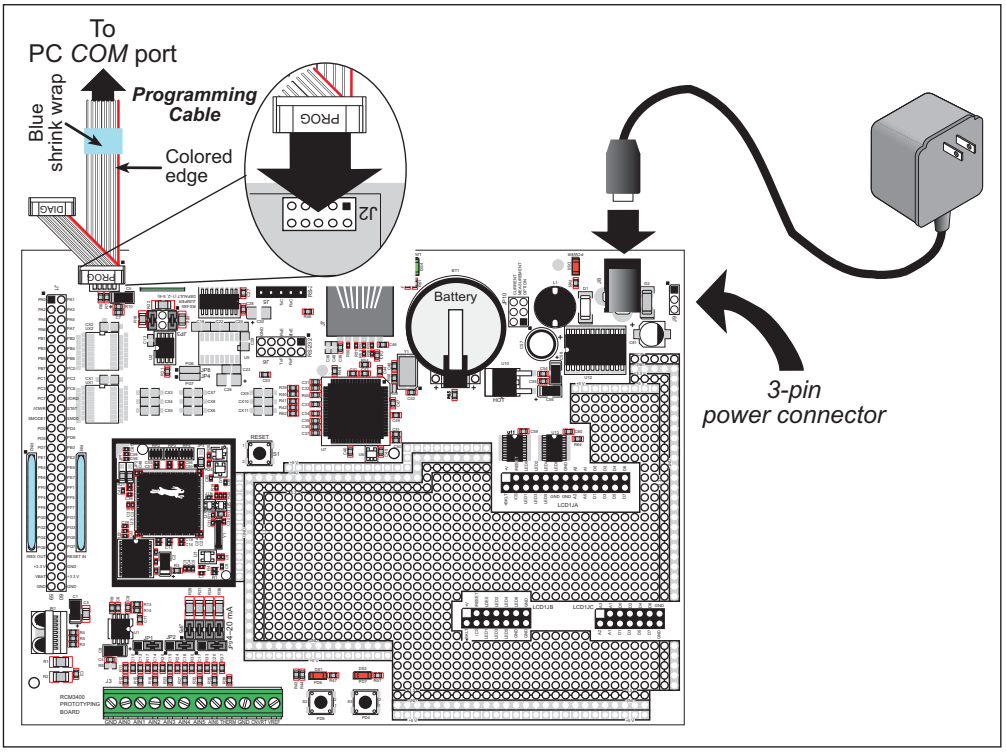


Figure 3. Connect Programming Cable and Power Supply

NOTE: Be sure to use the programming cable (part number 101-0542) supplied with this Development Kit—the programming cable has blue shrink wrap around the RS-232 converter section located in the middle of the cable. Programming cables with clear or red shrink wrap from other Rabbit Semiconductor kits are not designed to work with RCM3400 modules.

Connect the other end of the programming cable to a COM port on your PC.

NOTE: Some PCs now come equipped only with a USB port. It may be possible to use an RS-232/USB converter (Part No. 540-0070) with the programming cable supplied with the RCM3400 Development Kit. Note that not all RS-232/USB converters work with Dynamic C.

2.2.3 Connect Power

When all other connections have been made, you can connect power to the Prototyping Board. Connect the wall transformer to jack J8 on the Prototyping Board as shown in Figure 3.

Plug in the wall transformer. The power LED on the Prototyping Board should light up. The RCM3400 and the Prototyping Board are now ready to be used.

NOTE: A **RESET** button is provided on the Prototyping Board to allow a hardware reset without disconnecting power.

2.2.3.1 Overseas Development Kits

Development kits sold outside North America include a header connector that may be connected to 3-pin header J9 on the Prototyping Board. The connector may be attached either way as long as it is not offset to one side. The red and black wires from the connector can then be connected to the positive and negative connections on your power supply. The power supply should deliver 8 V–24 V DC at 8 W.

2.3 Run a Sample Program

If you already have Dynamic C installed, you are now ready to test your programming connections by running a sample program. Start Dynamic C by double-clicking on the Dynamic C icon or by double-clicking on **dcrab_XXXX.exe** in the Dynamic C root directory, where **XXXX** are version-specific characters. Dynamic C uses the serial port specified during installation.

If you are using a USB port to connect your computer to the RCM3400 module, choose **Options > Project Options** and select "Use USB to Serial Converter" under the **Communications** tab.

Find the file **PONG.C**, which is in the Dynamic C **SAMPLES** folder. To run the program, open it with the **File** menu, compile it using the **Compile** menu, and then run it by selecting **Run** in the **Run** menu. The **STDIO** window will open on your PC and will display a small square bouncing around in a box.

2.3.1 Troubleshooting

If you receive the message **No Rabbit Processor Detected**, the programming cable may be connected to the wrong COM port, a connection may be faulty, or the target system may not be powered up. First, check to see that the power LED on the Prototyping Board is lit and that the jumper across pins 5–6 of header JP10 on the Prototyping Board is installed. If the LED is lit, check both ends of the programming cable to ensure that it is firmly plugged into the PC and the programming port on the Prototyping Board. Ensure that the module is firmly and correctly installed in its connectors on the Prototyping Board.

If Dynamic C appears to compile the BIOS successfully, but you then receive a communication error message when you compile and load a sample program, it is possible that your PC cannot handle the higher program-loading baud rate. Try changing the maximum download rate to a slower baud rate as follows.

- Locate the **Serial Options** dialog in the Dynamic C **Options > Project Options > Communications** menu. Select a slower Max download baud rate.

If a program compiles and loads, but then loses target communication before you can begin debugging, it is possible that your PC cannot handle the default debugging baud rate. Try lowering the debugging baud rate as follows.

- Locate the **Serial Options** dialog in the Dynamic C **Options > Project Options > Communications** menu. Choose a lower debug baud rate.

If there are no faults with the hardware, select a different COM port within Dynamic C. From the **Options** menu, select **Project Options**, then select **Communications**. Select another COM port from the list, then click OK. Press **<Ctrl-Y>** to force Dynamic C to recompile the BIOS. If Dynamic C still reports it is unable to locate the target system, repeat the above steps until you locate the active COM port.You should receive a message **Bios compiled successfully** once this step is completed successfully.

2.4 Where Do I Go From Here?

If the sample program ran fine, you are now ready to go on to the sample programs in the ***RCM3400 User's Manual*** (click the documentation icon on your PC) and to develop your own applications. The sample programs can be easily modified for your own use. The user's manual also provides complete hardware reference information and software function calls for the RCM3400, the Prototyping Board, the Ethernet reference design, and the optional LCD/Keypad module.

For advanced development topics, refer to the ***Dynamic C User's Manual*** and the ***Dynamic C TCP/IP User's Manual***, also in the online documentation set.

2.4.1 Technical Support

NOTE: If you purchased your RCM3400 through a distributor or through a Rabbit Semiconductor partner, contact the distributor or partner first for technical support.

If there are any problems at this point:

- Use the Dynamic C **Help** menu to get further assistance with Dynamic C.
- Check the Rabbit Semiconductor Technical Bulletin Board at http://forums.digi.com/support/formum/index.
- Use the Technical Support e-mail form at http://www.digi.com/support.

3. RUNNING SAMPLE PROGRAMS

To develop and debug programs for the RCM3400 (and for all other Digi hardware), you must install and use Dynamic C. This chapter provides a tour of its major features with respect to the RCM3400.

3.1 Introduction

To help familiarize you with the RCM3400 modules, Dynamic C includes several sample programs. Loading, executing and studying these programs will give you a solid hands-on overview of the RCM3400's capabilities, as well as a quick start with Dynamic C as an application development tool.

> **NOTE:** The sample programs assume that you have at least an elementary grasp of ANSI C. If you do not, see the introductory pages of the ***Dynamic C User's Manual*** for a suggested reading list.

In order to run the sample programs discussed in this chapter and elsewhere in this manual,

1. Your RCM3400 must be plugged in to the Prototyping Board as described in Chapter 2, "Getting Started."
2. Dynamic C must be installed and running on your PC.
3. The programming cable must connect the programming header on the Prototyping Board to your PC.
4. Power must be applied to the RCM3400 through the Prototyping Board.

Refer to Chapter 2, "Getting Started," if you need further information on these steps.

To run a sample program, open it with the **File** menu (if it is not still open), compile it using the **Compile** menu (or press **F5**), and then run it by selecting **Run** in the **Run** menu (or press **F9**). The RCM3400 must be in Program Mode (see Figure 7) and must be connected to a PC using the programming cable.

More complete information on Dynamic C is provided in the ***Dynamic C User's Manual***.

3.2 Sample Programs

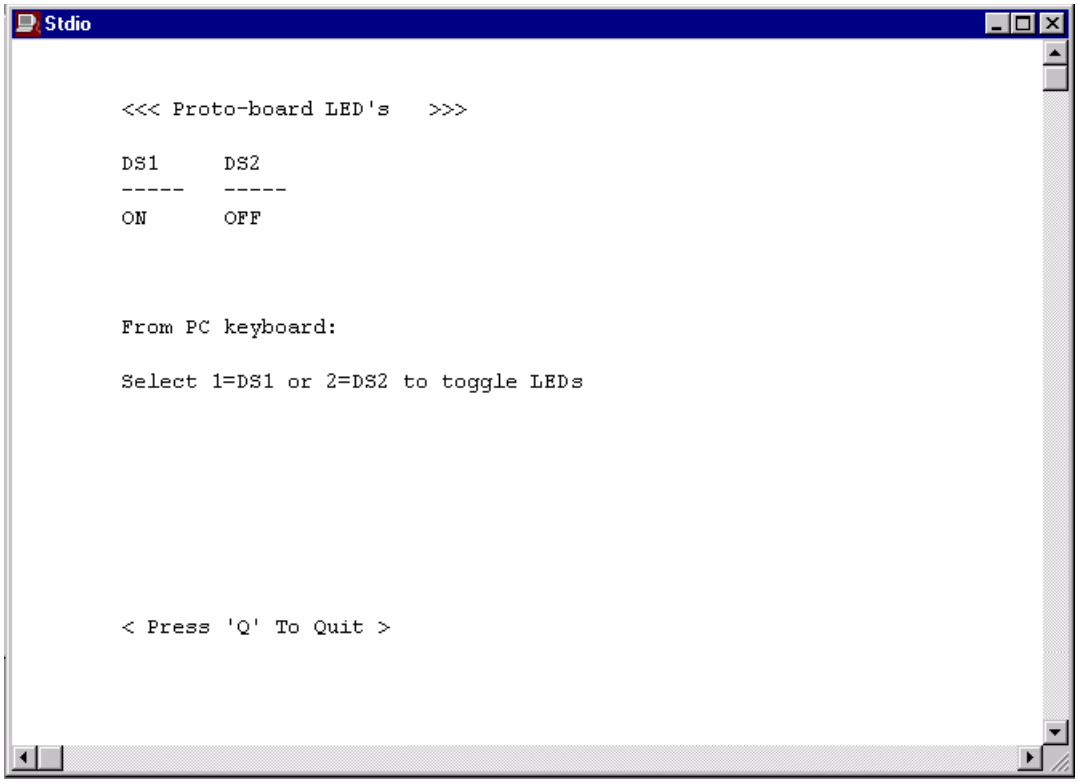
Of the many sample programs included with Dynamic C, several are specific to the RCM3400. These programs will be found in the **SAMPLES\RCM3400** folder.

Each sample program has comments that describe the purpose and function of the program. Follow the instructions at the beginning of the sample program.

- **CONTROLLED.C**—Demonstrates use of the digital inputs by having you turn LEDs DS1 and DS2 on the Prototyping Board on or off from the **STDIO** window on your PC.

  Parallel Port D bit 6 = LED DS1
  Parallel Port D bit 7 = LED DS2

  Once you compile and run **CONTROLLED.C**, the following display will appear in the Dynamic C **STDIO** window.



  Press "1" or "2" on your keyboard to select LED DS1 or DS2 on the Prototyping Board. Then follow the prompt in the Dynamic C **STDIO** window to turn the LED ON or OFF. A logic low will light up the LED you selected.

- **FLASHLED1.C**—demonstrates the use of assembly language to flash LEDs DS1 and DS2 on the Prototyping Board at different rates. Once you have compiled and run this program, LEDs DS1 and DS2 will flash on/off at different rates.
- **FLASHLED2.C**—demonstrates the use of cofunctions and costatements to flash LEDs DS1 and DS2 on the Prototyping Board at different rates. Once you have compiled and run this program, LEDs DS1 and DS2 will flash on/off at different rates.
- **TOGGLESWITCH.C**—demonstrates the use of costatements to detect switches using the press-and-release method of debouncing. LEDs DS1 and DS2 on the Prototyping Board are turned on and off when you press switches S2 and S3. S2 and S3 are controlled by PD5 and PD4 respectively.
- **IR_DEMO.C**—Demonstrates sending Modbus ASCII packets between two Prototyping Board assemblies via the IrDA transceivers with the IrDA transceivers facing each other. Note that this sample program requires a second Prototyping Board or Digi single-board computer that has an IrDA chip and is running the **IR_DEMO.C** sample program associated with it.

  First, compile and run the **IR_DEMO.C** sample program from the **SAMPLES** folder specific to the other system on the second system, then remove the programming cable and press the **RESET** button so that the first assembly is operating in the **Run** mode. Then connect the programming cable to the RCM3400 Prototyping Board, and compile and run the **IR_DEMO.C** sample program from the **SAMPLES\RCM3400** folder on the RCM3400 system. With the IrDA transceivers on the two Prototyping Boards facing each other, press switch S2 on the RCM3400 Prototyping Board to transmit a packet. The other system will return a response packet that will then appear in the Dynamic C **STDIO** window. The test packets and response packets have different codes.

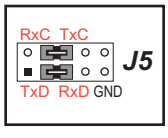
Once you have loaded and executed these five programs and have an understanding of how Dynamic C and the RCM3400 modules interact, you can move on and try the other sample programs, or begin building your own.

3.2.1 Serial Communication

The following sample programs are found in the **SERIAL** subdirectory in **SAMPLES\RCM3400**.

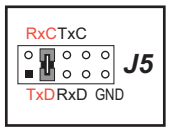
- **FLOWCONTROL.C**—This program demonstrates how to configure Serial Port C for CTS/RTS with serial data coming from Serial Port D (TxD) at 115,200 bps. The serial data received are displayed in the **STDIO** window.

  To set up the Prototyping Board, you will need to tie TxD and RxD together on the RS-232 header at J5, and you will also tie TxC and RxC together using the jumpers supplied in the Development Kit as shown in the diagram.



  A repeating triangular pattern should print out in the **STDIO** window. The program will periodically switch flow control on or off to demonstrate the effect of no flow control.

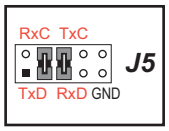
- **PARITY.C**—This program demonstrates the use of parity modes by repeatedly sending byte values 0–127 from Serial Port D to Serial Port C. The program will switch between generating parity or not on Serial Port D. Serial Port C will always be checking parity, so parity errors should occur during every other sequence.

  To set up the Prototyping Board, you will need to tie TxD and RxC together on the RS-232 header at J5 using one of the jumpers supplied in the Development Kit as shown in the diagram.

  The Dynamic C **STDIO** window will display the error sequence.

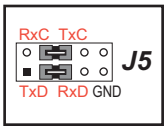
- **SIMPLE3WIRE.C**—This program demonstrates basic RS-232 serial communication. Lower case characters are sent by TxC, and are received by RxD. The characters are converted to upper case and are sent out by TxD, are received by RxC, and are displayed in the Dynamic C **STDIO** window.

  To set up the Prototyping Board, you will need to tie TxD and RxC together on the RS-232 header at J5, and you will also tie RxD and TxC together using the jumpers supplied in the Development Kit as shown in the diagram.

- **SIMPLE5WIRE.C**—This program demonstrates 5-wire RS-232 serial communication with flow control on Serial Port C and data flow on Serial Port D.

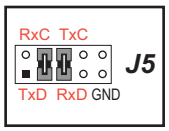
  To set up the Prototyping Board, you will need to tie TxD and RxD together on the RS-232 header at J5, and you will also tie TxC and RxC together using the jumpers supplied in the Development Kit as shown in the diagram.

  Once you have compiled and run this program, you can test flow control by disconnecting TxC from RxC while the program is running. Characters will no longer appear in the **STDIO** window, and will display again once TxC is connected back to RxC.

- **SWITCHCHAR.C**—This program demonstrates transmitting and then receiving an ASCII string on Serial Ports D and C. It also displays the serial data received from both ports in the **STDIO** window.

  To set up the Prototyping Board, you will need to tie TxD and RxC together on the RS-232 header at J5, and you will also tie RxD and TxC together using the jumpers supplied in the Development Kit as shown in the diagram.

  Once you have compiled and run this program, press and release S2 and S3 on the Prototyping Board. The data sent between the serial ports will be displayed in the **STDIO** window.

Two sample programs, **SIMPLE485MASTER.C** and **SIMPLE485SLAVE.C**, are available to illustrate RS-485 master/slave communication. To run these sample programs, you will need a second Rabbit-based system with RS-485.

The RS-485 connections between the slave and master devices are as follows.

- RS485+ to RS485+
- RS485– to RS485–
- GND to GND

- **SIMPLE485MASTER.C**—This program demonstrates a simple RS-485 transmission of lower case letters to a slave. The slave will send back converted upper case letters back to the master RCM3400 and display them in the **STDIO** window. Use **SIMPLE485SLAVE.C** to program the slave.
- **SIMPLE485SLAVE.C**—This program demonstrates a simple RS-485 transmission of lower case letters to a master RCM3400. The slave will send back converted upper case letters back to the master RCM3400 and display them in the **STDIO** window. Use **SIMPLE485MASTER.C** to program the master RCM3400.

3.2.2 A/D Converter Inputs

The following sample programs are found in the **ADC** subdirectory in **SAMPLES\RCM3400**.

- **AD_CAL_ALL.C**—Demonstrates how to recalibrate all single-ended analog input channels for one gain, using two known voltages to generate the calibration constants for each channel. Constants will be rewritten into the user block data area.
- **AD_CAL_CHAN.C**—Demonstrates how to recalibrate one single-ended analog input channel with one gain using two known voltages to generate the calibration constants for that channel. Constants will be rewritten into user block data area.
- **AD_CAL_DIFF.C**—Demonstrates how to recalibrate one differential analog input channel using two known voltages to generate the calibration constants for that channel. Constants will be rewritten into user block data area.
- **AD_CALMA_CH.C**—Demonstrates how to recalibrate an A/D input channel being used to convert analog current measurements to generate the calibration constants for that channel.

  NOTE: The above sample programs will overwrite any existing calibration constants.

- **AD_RDDIFF_CH.C**—Demonstrates how to read an A/D input channel being used for a differential input using previously defined calibration constants.
- **AD_RDMA_CH.C**—Demonstrates how to read an A/D input channel being used to convert analog current measurements using previously defined calibration constants for that channel.
- **AD_RDVOLT_ALL.C**—Demonstrates how to read all single-ended A/D input channels using previously defined calibration constants.
- **AD_SAMPLE.C**—Demonstrates how to use a low-level driver on single-ended inputs. The program will continuously display the voltage (average of 10 samples) that is present on the A/D channels.
- **ANAINCONFIG.C**—Demonstrates how to use the Register Mode method to read single-ended analog input values for display as voltages. The sample program uses the function call **anaInConfig()** and the ADS7870 CONVERT line to accomplish this task.

- **THERMISTOR.C**—Demonstrates how to use analog input THERM_IN7 to calculate temperature for display to the **STDIO** window. This sample program assumes that the thermistor is the one included in the Development Kit whose values for beta, series resistance, and resistance at standard temperature are given in the part specification.
- **DNLOADCALIB.C**—Demonstrates how to retrieve analog calibration data to rewrite it back to simulated EEPROM in flash with using a serial utility such as Tera Term.
- **UPLOADCALIB.C**—Demonstrates how to read calibrations constants from the user block in flash memory and then transmitting the file using a serial port and a PC serial utility such as Tera Term. Use **DNLOADCALIB.C** to download the calibration constants created by this program.

3.2.3 Real-Time Clock

If you plan to use the real-time clock functionality in your application, you will need to set the real-time clock. Set the real-time clock using the **SETRTCKB.C** sample program from the Dynamic C **SAMPLES\RTCLOCK** folder, using the onscreen prompts. The **RTC_TEST.C** sample program in the Dynamic C **SAMPLES\RTCLOCK** folder provides additional examples of how to read and set the real-time clock.

3.2.4 TCP/IP Sample Programs

Sample programs demonstrating the TCP/IP associated with the Prototyping Board are described in Appendix C.

3.2.5 LCD/Keypad Module Sample Programs

Sample programs for the optional LCD/keypad module are described in Appendix D.

4. HARDWARE REFERENCE

Chapter 4 describes the hardware components and principal hardware subsystems of the RCM3400. Appendix A, "RCM3400 Specifications," provides complete physical and electrical specifications.

Figure 4 shows the Rabbit-based subsystems designed into the RCM3400.

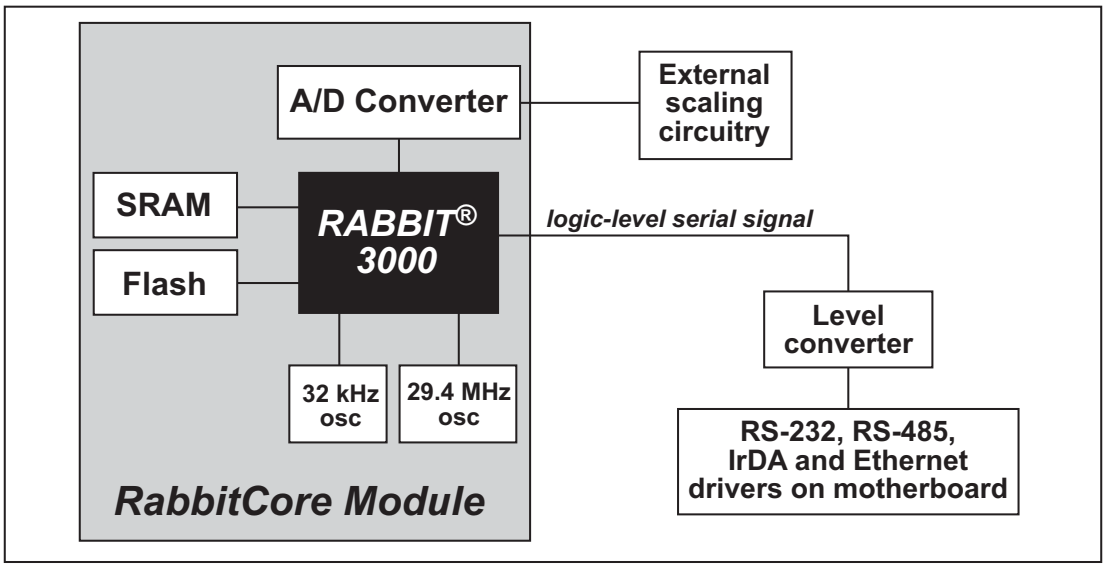


Figure 4. RCM3400 Subsystems

4.1 RCM3400 Digital Inputs and Outputs

Figure 5 shows the RCM3400 pinouts for headers J1 and J2.

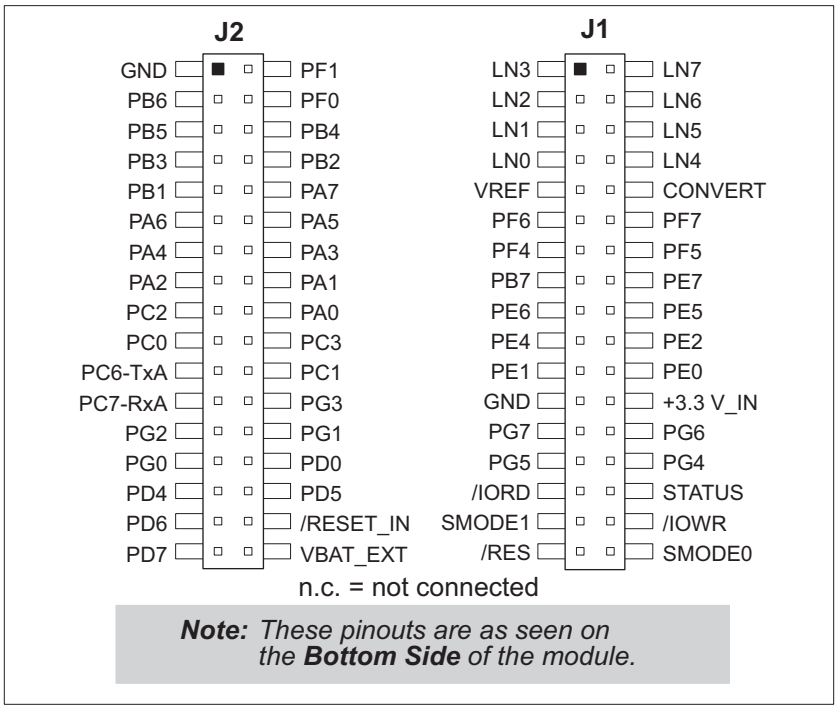


Figure 5. RCM3400 Pinouts

Headers J1 and J2 are standard 2 × 34 headers with a nominal 1.27 mm pitch.

Figure 6 shows the use of the Rabbit 3000 microprocessor ports in the RCM3400 modules.

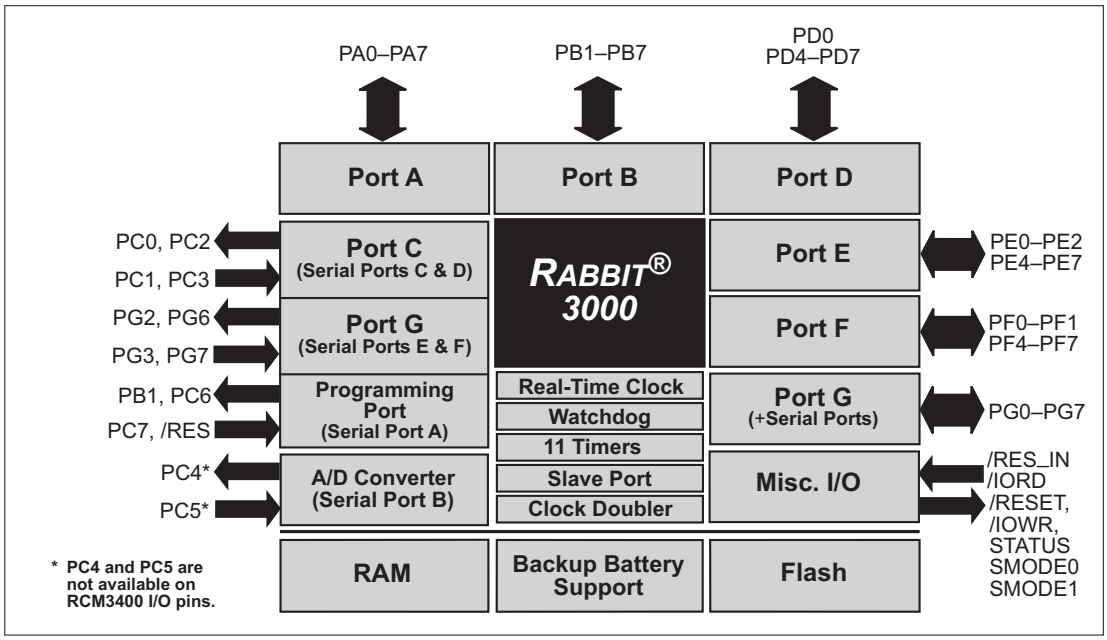


Figure 6. Use of Rabbit 3000 Ports

The ports on the Rabbit 3000 microprocessor used in the RCM3400 are configurable, and so the factory defaults can be reconfigured. Table 2 lists the Rabbit 3000 factory defaults and the alternate configurations.

Table 2. RCM3400 Pinout Configurations

Pin		Pin Name	Default Use	Alternate Use	Notes
Header J1	1	LN3	Analog Input		A/D converter
	2	LN7	Analog Input		
	3	LN2	Analog Input		
	4	LN6	Analog Input		
	5	LN1	Analog Input		
	6	LN5	Analog Input		
	7	LN0	Analog Input		
	8	LN4	Analog Input		
	9	VREF	Analog Output		1.15 V/2.048 V/2.500 V on-chip ref. voltage
	10	CONVERT	Analog Input		A/D converter
	11	PF6	Input/Output	AQD2B PWM2	
	12	PF7	Input/Output	AQD2A PWM3	
	13	PF4	Input/Output	AQD1B PWM0	
	14	PF5	Input/Output	AQD1A PWM1	
	15	PB7	Input/Output	IA5 /SLAVEATTN	External Address 5 Slave Attention
	16	PE7	Input/Output	I7 /SCS	I/O Strobe 7 Slave Port Chip Select
	17	PE6	Input/Output	I6	I/O Strobe 6
	18	PE5	Input/Output	I5 INT1B	I/O Strobe 5 Interrupt 1B
	19	PE4	Input/Output	I4 INT0B	I/O Strobe 4 Interrupt 0B
	20	PE2	Input/Output	I2	I/O Strobe 2
	21	PE1	Input/Output	I1 INT1A	I/O Strobe 1 Interrupt 1A
	22	PE0	Input/Output	I0 INT0A	I/O Strobe 0 Interrupt 0A

Table 2. RCM3400 Pinout Configurations (continued)

Pin		Pin Name	Default Use	Alternate Use	Notes
Header J1	23	GND			
	24	+3.3 V_IN			
	25	PG7	Input/Output	RXE	Serial Port E
	26	PG6	Input/Output	TXE	
	27	PG5	Input/Output	RCLKE	Serial Clock E input
	28	PG4	Input/Output	TCLKE	Serial Clock E output
	29	/IORD	Input		External read strobe
	30	STATUS	Output (Status)	Output	
	31	SMODE1	(SMODE1, SMODE0) (0,0)—start executing at address zero (0,1)—cold boot from slave port (1,0)—cold boot from clocked Serial Port A SMODE0 =1, SMODE1 = 1 Cold boot from asynchronous Serial Port A at 2400 bps (programming cable connected)		Programming port
	32	/IOWR	Output		External write strobe
	33	/RES	Reset output	Reset input	Reset output from Reset Generator
	34	SMODE0	(SMODE1, SMODE0) (0,0)—start executing at address zero (0,1)—cold boot from slave port (1,0)—cold boot from clocked Serial Port A SMODE0 =1, SMODE1 = 1 Cold boot from asynchronous Serial Port A at 2400 bps (programming cable connected)		Programming port

Table 2. RCM3400 Pinout Configurations (continued)

Pin		Pin Name	Default Use	Alternate Use	Notes
Header J2	1	GND			
	2	PF1	Input/Output	QD1A CLKC	
	3	PB6	Input/Output	IA4	External Address 4
	4	PF0	Input/Output	QD1B CLKD	
	5	PB5	Input/Output	IA3 SA1	External Address 3 Slave port Address 1
	6	PB4	Input/Output	IA2 SA0	External Address 2 Slave port Address 0
	7	PB3	Input/Output	IA1 /SRD	External Address 1 Slave port read
	8	PB2	Input/Output	IA0 /SWR	External Address 0 Slave port write
	9	PB1	Input/Output	CLKA	
	10–16	PA[7:1]	Parallel I/O	External data bus (ID7–ID1) Slave port data bus (SD7–SD1)	
	17	PC2	Output	TXC	Serial Port C
	18	PA0	Parallel I/O	External data bus (ID0) Slave port data bus (SD0)	High
	19	PC0	Output	TXD	Serial Port D
	20	PC3	Input	RXC	Serial Port C
	21	PC6	Output	TXA	Programming port
	22	PC1	Input	RXD	Serial Port D
	23	PC7	Input	RXA	Programming port
	24	PG3	Input/Output	RXF	Serial Port F
	25	PG2	Input/Output	TXF	
	26	PG1	Input/Output	RCLKF	Serial Clock F input
	27	PG0	Input/Output	TCLKF	Serial Clock F output
	28	PD0	Input/Output		
	29	PD4	Input/Output	ATXB	
	30	PD5	Input/Output	ARXB	

Table 2. RCM3400 Pinout Configurations (continued)

Pin		Pin Name	Default Use	Alternate Use	Notes
Header J2	31	PD6	Input/Output	ATXA	
	32	/RESET_IN	Input		Input to Reset Generator
	33	PD7	Input/Output	ARXA	
	34	VBAT_EXT			

4.1.1 Memory I/O Interface

The Rabbit 3000 address lines (A0–A19) and all the data lines (D0–D7) are routed internally to the onboard flash memory and SRAM chips. I/0 write (/IOWR) and I/0 read (/IORD) are available for interfacing to external devices.

Parallel Port A can also be used as an external I/O data bus to isolate external I/O from the main data bus. Parallel Port B pins PB2–PB7 can also be used as an auxiliary address bus.

When using the auxiliary I/O bus for either Ethernet or the LCD/keypad module on the Prototyping Board or for any other reason, you must add the following line at the beginning of your program.

```
#define PORTA_AUX_IO    // required to enable auxiliary I/O bus
```

4.1.2 Other Inputs and Outputs

The status, /RESET_IN, SMODE0, and SMODE1 I/O are normally associated with the programming port. Since the status pin is not used by the system once a program has been downloaded and is running, the status pin can then be used as a general-purpose CMOS output. The programming port is described in more detail in Section 4.2.2.

/RESET_IN is an external input used to reset the Rabbit 3000 microprocessor and the RCM3400 memory. /RES is an output from the reset circuitry that can be used to reset other peripheral devices.

The two SMODE pins, SMODE0 and SMODE1, are available as inputs. The logic state of these two pins determines the startup procedure after a reset.

4.2 Serial Communication

The RCM3400 board does not have any serial transceivers directly on the board. However, an Ethernet or other serial interface may be incorporated on the board the RCM3400 is mounted on. For example, the Prototyping Board has RS-232, RS-485, IrDA, and Ethernet transceiver chips.

4.2.1 Serial Ports

There are five serial ports designated as Serial Ports A, C, D, E, and F. All five serial ports can operate in an asynchronous mode up to the baud rate of the system clock divided by 8. An asynchronous port can handle 7 or 8 data bits. A 9th bit address scheme, where an additional bit is sent to mark the first byte of a message, is also supported.

Serial Port A is normally used as a programming port, but may be used either as an asynchronous or as a clocked serial port once application development has been completed and the RCM3400 is operating in the Run Mode.

Serial Port B is used by the A/D converter, and is not available for other use off the RCM3400.

Serial Ports C and D can also be operated in the clocked serial mode. In this mode, a clock line synchronously clocks the data in or out. Either of the two communicating devices can supply the clock.

Serial Ports E and F can also be configured as SDLC/HDLC serial ports. The IrDA protocol is also supported in SDLC format by these two ports.

4.2.2 Programming Port

The RCM3400 serial programming port is accessed via the 10-pin header labeled J2 on the Prototyping Board or over an Ethernet connection via the RabbitLink EG2110. The programming port uses the Rabbit 3000's Serial Port A for communication. Dynamic C uses the programming port to download and debug programs.

The programming port is also used for the following operations.

- Cold-boot the Rabbit 3000 on the RCM3400 after a reset.
- Remotely download and debug a program over an Ethernet connection using the RabbitLink EG2110.
- Fast copy designated portions of flash memory from one Rabbit-based board (the master) to another (the slave) using the Rabbit Cloning Board.

If the Prototyping Board is not used, programming must be initiated through the motherboard to which the RCM3400 module is plugged in to since the Serial Port A (PC6 and PC7), SMODE0, SMODE1, and /RESET_IN are available on headers J1 and J2 (see Table 2).

Alternate Uses of the Programming Port

All three clocked Serial Port A signals are available as

- a synchronous serial port
- an asynchronous serial port, with the clock line usable as a general CMOS I/O pin

The programming port may also be used as a serial port via the **DIAG** connector on the programming cable.

In addition to Serial Port A, the Rabbit 3000 startup-mode (SMODE0, SMODE1), status, and reset pins are available on the programming port.

The two startup mode pins determine what happens after a reset—the Rabbit 3000 is either cold-booted or the program begins executing at address 0x0000.

The status pin is used by Dynamic C to determine whether a Rabbit microprocessor is present. The status output has three different programmable functions:

1. It can be driven low on the first op code fetch cycle.
2. It can be driven low during an interrupt acknowledge cycle.
3. It can also serve as a general-purpose output.

The /RESET_IN pin is an external input that is used to reset the Rabbit 3000 and the RCM3400 onboard peripheral circuits. The serial programming port can be used to force a hard reset on the RCM3400 by asserting the /RESET_IN signal.

Refer to the ***Rabbit 3000 Microprocessor User's Manual*** for more information.

4.3 Serial Programming Cable

The programming cable is used to connect the serial programming port of the RCM3400 to a PC serial COM port. The programming cable converts the RS-232 voltage levels used by the PC serial port to the CMOS voltage levels used by the Rabbit 3000.

When the **PROG** connector on the programming cable is connected to the programming header on the RCM3400 Prototyping Board, programs can be downloaded and debugged over the serial interface.

The **DIAG** connector of the programming cable may be used on header J2 of the RCM3400 Prototyping Board with the RCM3400 operating in the Run Mode. This allows the programming port to be used as a regular serial port.

4.3.1 Changing Between Program Mode and Run Mode

The RCM3400 is automatically in Program Mode when the **PROG** connector on the programming cable is attached, and is automatically in Run Mode when no programming cable is attached. When the Rabbit 3000 is reset, the operating mode is determined by the status of the SMODE pins. When the programming cable's **PROG** connector is attached, the SMODE pins are pulled high, placing the Rabbit 3000 in the Program Mode. When the programming cable's **PROG** connector is not attached, the SMODE pins are pulled low, causing the Rabbit 3000 to operate in the Run Mode.

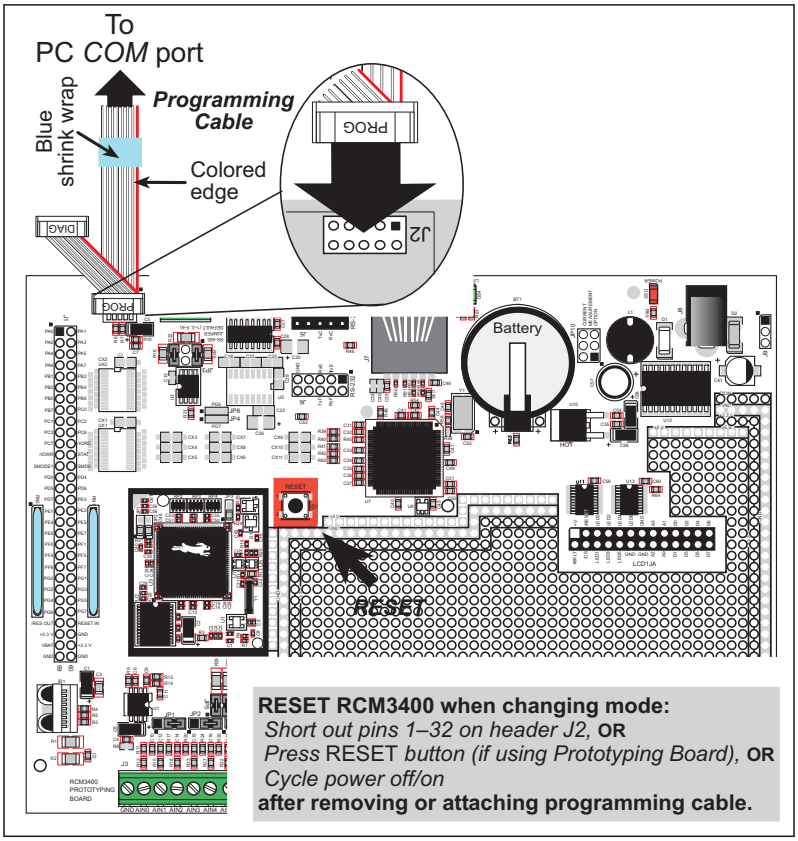


Figure 7. Switching Between Program Mode and Run Mode

A program "runs" in either mode, but can only be downloaded and debugged when the RCM3400 is in the program mode.

Refer to the ***Rabbit 3000 Microprocessor User's Manual*** for more information on the programming port and the programming cable.

4.3.2 Standalone Operation of the RCM3400

The RCM3400 must be programmed via the RCM3400 Prototyping Board or via a similar arrangement on a customer-supplied board. Once the RCM3400 has been programmed successfully, remove the programming cable from the programming connector and reset the RCM3400. The RCM3400 may be reset by cycling power off/on or by pressing the **RESET** button on the Prototyping Board. The RCM3400 module may now be removed from the Prototyping Board for end-use installation.

CAUTION: Power to the Prototyping Board or other boards should be disconnected when removing or installing your RCM3400 module to protect against inadvertent shorts across the pins or damage to the RCM3400 if the pins are not plugged in correctly. Do not reapply power until you have verified that the RCM3400 module is plugged in correctly.

4.4 A/D Converter

The RCM3400 has an onboard ADS7870 A/D converter whose scaling and filtering are done via the motherboard on which the RCM3400 module is mounted. The A/D converter multiplexes converted signals from eight single-ended or four differential inputs to Serial Port B on the Rabbit 3000.

The eight analog input pins, LN0–LN7, each have an input impedance of 6–7 MΩ, depending on whether they are used as single-ended or differential inputs. The input signal can range from -2 V to +2 V (differential mode) or from 0 V to +2 V (single-ended mode).

Use a resistor divider such as the one shown in Figure 8 for the analog inputs.

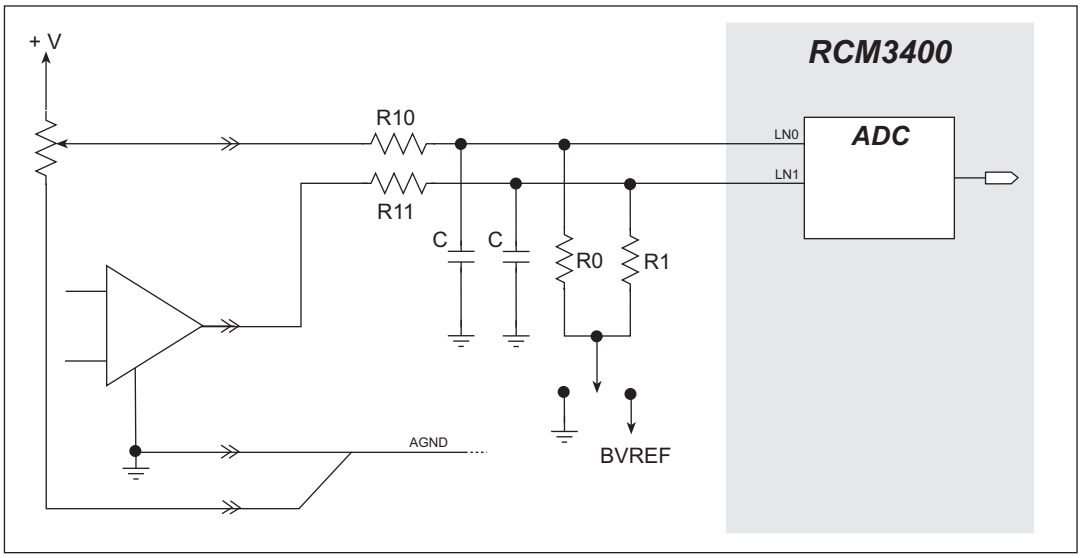


Figure 8. Resistor Divider Network for Analog Inputs

R0 and R1 are typically 20 kΩ to 100 kΩ, with a lower resistance leading to more accuracy, but at the expense of a higher current draw. R10 and R11 would then be 180 kΩ to 900 kΩ for a 10:1 attenuator. The capacitor filters noise pulses on the A/D converter input.

The actual voltage range for a signal going to the A/D converter input is also affected by the 1, 2, 4, 5. 8, 10, 16, and 20 V/V software-programmable gains available on each channel of the ADS7870 A/D converter. Thus, you must scale the analog signal with an attenuator circuit and a software-programmable gain so that the actual input presented to the A/D converter is within the range limits of the ADS7870 A/D converter chip (-2 V to + 2 V or 0 V to + 2 V).

The A/D converter chip can only accept positive voltages. With resistors R0 and R1 connected to ground, your analog circuit is well-suited to perform positive A/D conversions. When R0 and R1 are tied to ground for differential measurements, both differential inputs must be referenced to analog ground, and ***both inputs must be positive with respect to analog ground***.

If a device such as a battery is connected across two channels for a differential measurement, and it is ***not*** referenced to analog ground, then the current from the device will flow through both sets of attenuator resistors as shown in Figure 9. This will generate a negative voltage at one of the inputs, LN1, which will almost certainly lead to inaccurate A/D conversions. To make such differential measurements, connect R0 and R1 to the A/D converter's internal reference voltage, which is software-configurable for 1.15 V, 2.048 V, or 2.5 V. This internal reference voltage is available on pin 9 of header J1 as VREF, and allows you to convert analog input voltages that are negative with respect to analog ground.

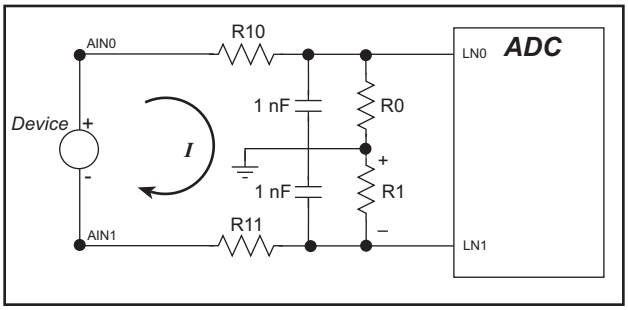


Figure 9. Current Flow from Ungrounded or Floating Source

NOTE: The amplifier inside the A/D converter's internal voltage reference circuit has a very limited output-current capability. The internal buffer can source up to 20 mA and sink only up to 20 µA. Use a separate buffer amplifier if you need to supply any load current.

The A/D converter's CONVERT pin is available on pin 10 of header J1 and can be used as a hardware means of forcing the A/D converter to start a conversion cycle. The CONVERT signal is an edge-triggered event and has a hold time of two CCLK periods for debounce.

A conversion is started by an active (rising) edge on the CONVERT pin. The CONVERT pin must stay low for at least two CCLK periods before going high for at least two CCLK periods. Figure 10 shows the timing of a conversion start. The double falling arrow on CCLK indicates the actual start of the conversion cycle.

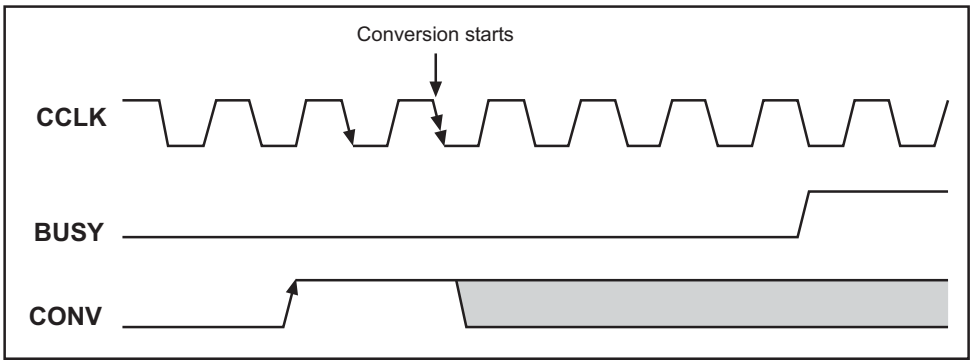


Figure 10. Timing Diagram for Conversion Start Using CONVERT Pin

Appendix B explains the implementation examples of these features on the Prototyping Board.

4.4.1 A/D Converter Calibration

All single-ended inputs are factory-calibrated with actual voltages at a gain code of 0. Typical values for the other gain codes and for other calibration constants for current and differential measurements are used to populate the table to allow A/D conversions to be done "out of the box." See Appendix B.4.3.3 for information on performing your own calibrations in situations where you require enhanced accuracy.

4.4.2 A/D Converter Power Supply

The analog section is isolated from digital noise generated by other components by way of a low-pass filter composed of L1, C10, and C15 on the RCM3400 as shown in Figure 11. The +V analog power supply powers the A/D converter chip.

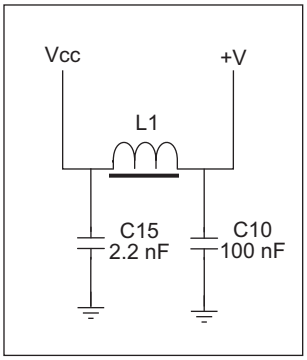


Figure 11. Analog Supply Circuit

4.5 Other Hardware

4.5.1 Clock Doubler

The RCM3400 takes advantage of the Rabbit 3000 microprocessor's internal clock doubler. A built-in clock doubler allows half-frequency crystals to be used to reduce radiated emissions. The 29.4 MHz frequency specified for the RCM3400 is generated using a 14.7 MHz resonator.

The clock doubler may be disabled if 29.4 MHz clock speeds are not required. Disabling the Rabbit 3000 microprocessor's internal clock doubler will reduce power consumption and further reduce radiated emissions. The clock doubler is disabled with a simple configuration macro as shown below.

1. Select the "Defines" tab from the Dynamic C **Options > Project Options** menu.
2. Add the line **CLOCK_DOUBLED=0** to always disable the clock doubler.

   The clock doubler is enabled by default, and usually no entry is needed. If you need to specify that the clock doubler is always enabled, add the line **CLOCK_DOUBLED=1** to always enable the clock doubler.
3. Click **OK** to save the macro. The clock doubler will now remain off whenever you are in the project file where you defined the macro.

The clock doubler ***must*** be disabled for low-voltage operation (2.8 V–3.0 V).

4.5.2 Spectrum Spreader

The Rabbit 3000 features a spectrum spreader, which helps to mitigate EMI problems. The spectrum spreader is on by default, but it may also be turned off or set to a stronger setting. The means for doing so is through a simple configuration macro as shown below.

1. Select the "Defines" tab from the Dynamic C **Options > Project Options** menu.
2. Normal spreading is the default, and usually no entry is needed. If you need to specify normal spreading, add the line

   ```
   ENABLE_SPREADER=1
   ```

   For strong spreading, add the line

   ```
   ENABLE_SPREADER=2
   ```

   To disable the spectrum spreader, add the line

   ```
   ENABLE_SPREADER=0
   ```

   NOTE: The strong spectrum-spreading setting is unnecessary for the BL2000.
3. Click **OK** to save the macro. The spectrum spreader will now remain off whenever you are in the project file where you defined the macro.

NOTE: Refer to the ***Rabbit 3000 Microprocessor User's Manual*** for more information on the spectrum-spreading setting and the maximum clock speed.

4.6 Memory

4.6.1 SRAM

RCM3400 boards have 256K–512K of SRAM installed at U6.

4.6.2 Flash EPROM

RCM3400 boards also have 256K–512K of flash EPROM installed at U4.

> **NOTE:** Digi recommends that any customer applications should not be constrained by the sector size of the flash EPROM since it may be necessary to change the sector size in the future.

Writing to arbitrary flash memory addresses at run time is also discouraged. Instead, define a "user block" area to store persistent data. The functions **`writeUserBlock`** and **`readUserBlock`** are provided for this. Refer to the ***Rabbit 3000 Microprocessor Designer's Handbook*** for additional information.

A Flash Memory Bank Select jumper configuration option based on 0 Ω surface-mounted resistors exists at header JP2 on the RCM3400 modules. This option is reserved for future use.

4.6.3 Dynamic C BIOS Source Files

The Dynamic C BIOS source files handle different standard RAM and flash EPROM sizes automatically.

5. SOFTWARE REFERENCE

Dynamic C is an integrated development system for writing embedded software. It runs on an IBM-compatible PC and is designed for use with Rabbit Semiconductor controllers and other controllers based on the Rabbit microprocessor. Chapter 5 provides the libraries, function calls, and sample programs related to the RCM3400.

5.1 More About Dynamic C

Dynamic C has been in use worldwide since 1989. It is specially designed for programming embedded systems, and features quick compile and interactive debugging in the real environment. A complete reference guide to Dynamic C is contained in the ***Dynamic C User's Manual***.

You have the choice of doing your software development in the flash memory or in the static SRAM included on the RCM3400. The flash memory and SRAM options are selected with the **Options > Compiler** menu.

The advantage of working in RAM is to save wear on the flash memory, which is limited to about 100,000 write cycles. The disadvantage is that the code and data might not both fit in RAM.

NOTE: An application can be developed in RAM, but cannot run standalone from RAM after the programming cable is disconnected. All standalone applications can only run from flash memory.

NOTE: Do not depend on the flash memory sector size or type. Due to the volatility of the flash memory market, the RCM3400 and Dynamic C were designed to accommodate flash devices with various sector sizes.

Developing software with Dynamic C is simple. Users can write, compile, and test C and assembly code without leaving the Dynamic C development environment. Debugging occurs while the application runs on the target. Alternatively, users can compile a program to an image file for later loading. Dynamic C runs on PCs under Windows 95, 98, 2000, NT, Me, and XP. Programs can be downloaded at baud rates of up to 460,800 bps after the program compiles.

Dynamic C has a number of standard features:

- Full-feature source and/or assembly-level debugger, no in-circuit emulator required.
- Royalty-free TCP/IP stack with source code and most common protocols.
- Hundreds of functions in source-code libraries and sample programs:
  - Exceptionally fast support for floating-point arithmetic and transcendental functions.
  - RS-232 and RS-485 serial communication.
  - Analog and digital I/O drivers.
  - I^2C, SPI, GPS, file system.
  - LCD display and keypad drivers.
- Powerful language extensions for cooperative or preemptive multitasking
- Loader utility program to load binary images into Rabbit Semiconductor targets in the absence of Dynamic C.
- Provision for customers to create their own source code libraries and augment on-line help by creating "function description" block comments using a special format for library functions.
- Standard debugging features:
  - Breakpoints—Set breakpoints that can disable interrupts.
  - Single-stepping—Step into or over functions at a source or machine code level, µC/OS-II aware.
  - Code disassembly—The disassembly window displays addresses, opcodes, mnemonics, and machine cycle times. Switch between debugging at machine-code level and source-code level by simply opening or closing the disassembly window.
  - Watch expressions—Watch expressions are compiled when defined, so complex expressions including function calls may be placed into watch expressions. Watch expressions can be updated with or without stopping program execution.
  - Register window—All processor registers and flags are displayed. The contents of general registers may be modified in the window by the user.
  - Stack window—shows the contents of the top of the stack.
  - Hex memory dump—displays the contents of memory at any address.
  - **STDIO** window—**`printf`** outputs to this window and keyboard input on the host PC can be detected for debugging purposes. **`printf`** output may also be sent to a serial port or file.

5.2 Dynamic C Function Calls

5.2.1 Digital I/O

The RCM3400 was designed to interface with other systems, and so there are no drivers written specifically for the I/O. The general Dynamic C read and write functions allow you to customize the parallel I/O to meet your specific needs. For example, use

```
WrPortI(PEDDR, &PEDDRShadow, 0x00);
```

to set all the Port E bits as inputs, or use

```
WrPortI(PEDDR, &PEDDRShadow, 0xFF);
```

to set all the Port E bits as outputs.

When using the auxiliary I/O bus on the Rabbit 3000 chip, add the line

```
#define PORTA_AUX_IO    // required to enable auxiliary I/O bus
```

to the beginning of any programs using the auxiliary I/O bus.

The sample programs in the Dynamic C **SAMPLES/RCM3400** directory provide further examples.

5.2.2 Serial Communication Drivers

Library files included with Dynamic C provide a full range of serial communications support. The **RS232.LIB** library provides a set of circular-buffer-based serial functions. The **PACKET.LIB** library provides packet-based serial functions where packets can be delimited by the 9th bit, by transmission gaps, or with user-defined special characters. Both libraries provide blocking functions, which do not return until they are finished transmitting or receiving, and nonblocking functions, which must be called repeatedly until they are finished. For more information, see the ***Dynamic C Function Reference Manual*** and Technical Note 213, ***Rabbit 2000 Serial Port Software***.

5.2.3 TCP/IP Drivers

The TCP/IP drivers are located in the **TCPIP** directory.

Complete information on these libraries and the TCP/IP functions is provided in the ***Dynamic C TCP/IP User's Manual***.

5.2.4 Prototyping Board Function Calls

The functions described in this section are for use with the Prototyping Board features. The source code is in the **RCM34xx.LIB** library in the Dynamic C **LIB\RCM3400** folder if you need to modify it for your own board design.

Other generic functions applicable to all devices based on Rabbit microprocessors are described in the ***Dynamic C Function Reference Manual***.

5.2.5 Board Initialization

```
void brdInit (void);
```

Call this function at the beginning of your program. This function initializes Parallel Ports A through G for use with the RCM3400 Prototyping Board.

Summary of Initialization

1. Display/keypad select is disabled.
2. Ethernet select is disabled.
3. RS-485 is not enabled.
4. RS-232 is not enabled.
5. Unused configurable I/O are tied inputs or outputs set low.
6. A/D converter is reset and SCLKB is set to 57,600 bps.
7. A/D converter calibration constants are read, so this function cannot run in RAM.

RETURN VALUE

None.

5.2.6 Analog Inputs

```
unsigned int anaInConfig(unsigned int
   instructionbyte, unsigned int cmd, long baud);
```

Use this function to configure the A/D converter. This function will address the A/D converter in Register Mode only, and will return an error if you try the Direct Mode. Appendix B.4.3 provides additional addressing and command information.

ADS7870 Signal	ADS7870 State	RCM3400 Function/State
LN0	Input	AIN0
LN1	Input	AIN1
LN2	Input	AIN2
LN3	Input	AIN3
LN4	Input	AIN4
LN5	Input	AIN5
LN6	Input	AIN6
LN7	Input	AIN7
/RESET	Input	Board reset device
RISE/FALL	Input	Pulled up for SCLK active on rising edge
PIO0	Input	Pulled down
PIO1	Input	Pulled down
PIO2	Input	Pulled down
PIO3	Input	Pulled down
CONVERT	Input	Pulled down
BUSY	Output	PD1 pulled down; logic high state converter is busy
CCLKCNTRL	Input	Pulled down; 0 state sets CCLK as input
CCLK	Input	Pulled down; external conversion clock
SCLK	Input	PB0; serial data transfer clock
SDI	Input	PC4; 3-wire mode for serial data input
SDO	Output	PC5; serial data output /CS driven
/CS	Input	PD2 pulled up; active-low enables serial interface
BUFIN	Input	Pulled down; reference buffer amplifier
VREF	Output	Connected to BUFIN
BUFOUT	Output	Pulled down

PARAMETERS

instructionbyte is the instruction byte that will initiate a read or write operation at 8 or 16 bits on the designated register address. For example,

```
checkid = anaInConfig(0x5F, 0, 9600);  // read ID and set baud rate
```

cmd are the command data that configure the registers addressed by the instruction byte. Enter 0 if you are performing a read operation. For example,

```
i = anaInConfig(0x07, 0x3b, 0);  // write ref/osc reg and enable
```

baud is the serial clock transfer rate of 9600 to 57,600 bps. **baud** must be set the first time this function is called. Enter 0 for this parameter thereafter, for example,

```
anaInConfig(0x00, 0x00, 9600);  // resets device and sets baud
```

RETURN VALUE

0 on write operations,
data value on read operations

SEE ALSO

anaInDriver, anaIn, brdInit

unsigned int anaInDriver(unsigned int cmd, unsigned int len);

Reads the voltage of an analog input channel by serial-clocking an 8-bit command to the A/D converter by its Direct Mode method. This function assumes that Mode1 (most significant byte first) and the A/D converter oscillator have been enabled. See **`anaInConfig()`** for the setup.

The conversion begins immediately after the last data bit has been transferred. An exception error will occur if Direct Mode bit D7 is not set.

PARAMETERS

`cmd` contains a gain code and a channel code as follows.

D7—1; D6–D4—Gain Code; D3–D0—Channel Code

Use the following calculation and the tables below to determine **`cmd`**:

```
cmd = 0x80 | (gain_code*16) + channel_code
```

Gain Code	Multiplier
0	×1
1	×2
2	×4
3	×5
4	×8
5	×10
6	×16
7	×20

Channel Code	Differential Input Lines	Channel Code	Single-Ended Input Lines*	4–20 mA Lines
0	+AIN0 -AIN1	8	AIN0	AIN0*
1	+AIN2 -AIN3	9	AIN1	AIN1*
2	+AIN4 -AIN5	10	AIN2	AIN2*
3†	+AIN6 -AIN7	11	AIN3	AIN3
4	-AIN0 +AIN1	12	AIN4	AIN4
5	-AIN2 +AIN3	13	AIN5	AIN5
6	-AIN4 +AIN5	14	AIN6	AIN6
7*	-AIN6 +AIN7	15	AIN7	AIN7*

* Negative input is ground.
† Not accessible on Prototyping Board

`len`, the output bit length, is always 12 for 11-bit conversions

RETURN VALUE

A value corresponding to the voltage on the analog input channel:

0–2047 for 11-bit conversions (bit 12 for sign)
-1 overflow or out of range
-2 conversion incomplete, busy bit timeout

SEE ALSO

anaInConfig, anaIn, brdInit

unsigned int anaIn(unsigned int channel, int opmode, int gaincode);

Reads the value of an analog input channel using the direct method of addressing the A/D converter. Note that it takes about 1 second to ensure an internal capacitor on the A/D converter is charged when the function is called the first time.

PARAMETERS

channel is the channel number (0 to 7) corresponding to ADC_IN0 to ADC_IN7

opmode is the mode of operation:

SINGLE—single-ended input
DIFF—differential input
mAMP—4–20 mA input

channel	SINGLE	DIFF	mAMP
0	+AIN0	+AIN0 -AIN1	+AIN0*
1	+AIN1	+AIN1 -AIN0*	+AIN1*
2	+AIN2	+AIN2 -AIN3	+AIN2*
3	+AIN3	+AIN3 -AIN2*	+AIN3
4	+AIN4	+AIN4 -AIN5	+AIN4
5	+AIN5	+AIN5 -AIN4*	+AIN5
6	+AIN6	+AIN6 -AIN7*	+AIN6
7	+AIN7	+AIN7 -AIN6*	+AIN7*

* Not accessible on Prototyping Board.

gaincode is the gain code of 0 to 7 (applies only to Prototyping Board):

Gain Code	Multiplier	Voltage Range (V)
0	×1	0–20
1	×2	0–10
2	×4	0–5
3	×5	0–4
4	×8	0–2.5
5	×10	0–2
6	×16	0–1.25
7	×20	0–1

RETURN VALUE

A value corresponding to the voltage on the analog input channel:

0–2047 for 11-bit A/D conversions (bit 12 for sign)
ADOVERFLOW (defined macro = -4096) if overflow or out of range
ADTIMEOUT (defined macro = -4095) if conversion is incomplete or busy-bit timeout

SEE ALSO

anaIn, anaInConfig, anaInDriver

```
int anaInCalib(int channel, int opmode,
   int gaincode, int value1, float volts1,
   int value2, float volts2);
```

Calibrates the response of the desired A/D converter channel as a linear function using the two conversion points provided. Four values are calculated and placed into global tables **_adcCalibS**, **_adcCalibD**, and **adcCalibM** to be later stored into simulated EEPROM using the function **anaInEEWr()**. Each channel will have a linear constant and a voltage offset.

PARAMETERS

channel is the analog input channel number (0 to 7) corresponding to ADC_IN0 to ADC_IN7

opmode is the mode of operation:

SINGLE—single-ended input
DIFF—differential input
mAMP—milliamp input

channel	SINGLE	DIFF	mAMP
0	+AIN0	+AIN0 -AIN1	+AIN0*
1	+AIN1	+AIN1 -AIN0*	+AIN1*
2	+AIN2	+AIN2 -AIN3	+AIN2*
3	+AIN3	+AIN3 -AIN2*	+AIN3
4	+AIN4	+AIN4 -AIN5	+AIN4
5	+AIN5	+AIN5 -AIN4*	+AIN5
6	+AIN6	+AIN6 -AIN7*	+AIN6
7	+AIN7	+AIN7 -AIN6*	+AIN7*

* Not accessible on Prototyping Board.

gaincode is the gain code of 0 to 7:

Gain Code	Multiplier	Voltage Range* (V)
0	×1	0–20
1	×2	0–10
2	×4	0–5
3	×5	0–4
4	×8	0–2.5
5	×10	0–2
6	×16	0–1.25
7	×20	0–1

* Applies to Prototyping Board.

value1 is the first A/D converter channel raw count value

volts1 is the voltage or current corresponding to the first A/D converter channel value (0 to +20 V or 4 to 20 mA)

value2 is the second A/D converter channel raw count value

volts2 is the voltage or current corresponding to the first A/D converter channel value (0 to +20 V or 4 to 20 mA)

RETURN VALUE

0 if successful.
-1 if not able to make calibration constants.

SEE ALSO

anaIn, anaInVolts, anaInmAmps, anaInDiff, anaInCalib, brdInit

float anaInVolts(unsigned int channel, unsigned int gaincode);

Reads the state of a single-ended analog input channel and uses the previously set calibration constants to convert it to volts.

PARAMETERS

channel is the channel number (0 to 7) corresponding to ADC_IN0 to ADC_IN7

Channel Code	Single-Ended Input Lines*	Voltage Range† (V)
0	+AIN0	0–20
1	+AIN1	0–20
2	+AIN2	0–20
3	+AIN3	0–20
4	+AIN4	0–20
5	+AIN5	0–20
6	+AIN6	0–20
7	+AIN7	0–2‡

* Negative input is ground.
† Applies to Prototyping Board.
‡ Used for thermistor in sample program.

gaincode is the gain code of 0 to 7.

Gain Code	Multiplier	Voltage Range* (V)
0	×1	0–20
1	×2	0–10
2	×4	0–5
3	×5	0–4
4	×8	0–2.5
5	×10	0–2
6	×16	0–1.25
7	×20	0–1

* Applies to RCM3400 Prototyping Board.

RETURN VALUE

A voltage value corresponding to the voltage on the analog input channel.

ADOVERFLOW (defined macro = -4096) if overflow or out of range.

ADTIMEOUT (defined macro = -4095) if conversion is incomplete or busy-bit timeout.

SEE ALSO

anaInCalib, anaIn, anaInmAmps, brdInit

float anaInDiff(unsigned int channel, unsigned int gaincode);

Reads the state of differential analog input channels and uses the previously set calibration constants to convert it to volts.

PARAMETERS

channel is the analog input channel number (0 to 7) corresponding to ADC_IN0 to ADC_IN7

channel	DIFF	Voltage Range (V)
0	+AIN0 -AIN1	-20 to +20*
1	+AIN1 -AIN1	—
2	+AIN2 -AIN3	-20 to +20*
3	+AIN3 -AIN3	—
4	+AIN4 -AIN5	-20 to +20*
5	+AIN5 -AIN5	—
6	+AIN6 -AIN7	—
7	+AIN7 -AIN7	—

* Accessible on Prototyping Board.

gaincode is the gain code of 0 to 7.

Gain Code	Multiplier	Voltage Range* (V)
0	×1	-20 – +20
1	×2	-10 – +10
2	×4	-5 – +5
3	×5	-4 – +4
4	×8	-2.5 – +2.5
5	×10	-2 – +2
6	×16	-1.25 – +1.25
7	×20	-1 – +1

* Applies to Prototyping Board.

RETURN VALUE

A voltage value corresponding to the voltage differential on the analog input channel.

ADOVERFLOW (defined macro = -4096) if overflow or out of range.

ADTIMEOUT (defined macro = -4095) if conversion is incomplete or busy-bit timeout.

SEE ALSO

anaInCalib, anaIn, anaInmAmps, brdInit

float anaInmAmps(unsigned int channel);

Reads the state of an analog input channel and uses the previously set calibration constants to convert it to current.

PARAMETERS

channel is the channel number (0–7):

Channel Code	4–20 mA Input Lines*
0	+AIN0
1	+AIN1
2	+AIN2
3	+AIN3†
4	+AIN4*
5	+AIN5*
6	+AIN6*
7	+AIN7

* Negative input is ground.

† Applies to Prototyping Board.

RETURN VALUE

A current value between 4.00 and 20.00 mA corresponding to the current on the analog input channel.

ADOVERFLOW (defined macro = -4096) if overflow or out of range.

ADTIMEOUT (defined macro = -4095) if conversion is incomplete or busy-bit timeout.

SEE ALSO

anaInCalib, anaIn, anaInVolts

root int anaInEERd(unsigned int channel, unsigned int opmode, unsigned int gaincode);

Reads the calibration constants, gain, and offset for an input based on their designated position in the simulated EEPROM area of the flash memory, and places them into global tables **_adcCalibS**, **_adcCalibD**, and **_adcCalibM** for analog inputs. The constants are stored in the top 2K of the user block in a reserved memory area. Depending on the flash size, the following macros can be used to identify the starting address for these locations.

ADC_CALIB_ADDRS, address start of single-ended analog input channels

ADC_CALIB_ADDRD, address start of differential analog input channels

ADC_CALIB_ADDRM, address start of milliamp analog input channels

NOTE: This function cannot be run in RAM.

PARAMETER

channel is the analog input channel number (0 to 7) corresponding to ADC_IN0 to ADC_IN7.

opmode is the mode of operation:

SINGLE—single-ended input line
DIFF—differential input line
mAMP—milliamp input line

channel	SINGLE	DIFF	mAMP
0	+AIN0	+AIN0 -AIN1	+AIN0*
1	+AIN1	+AIN1 -AIN0*	+AIN1*
2	+AIN2	+AIN2 -AIN3	+AIN2*
3	+AIN3	+AIN3 -AIN2*	+AIN3
4	+AIN4	+AIN4 -AIN5	+AIN4
5	+AIN5	+AIN5 -AIN4*	+AIN5
6	+AIN6	+AIN6 -AIN7*	+AIN6
7	+AIN7	+AIN7 -AIN6*	+AIN7*
ALLCHAN	read all channels for selected **opmode**		

* Not accessible on Prototyping Board.

gaincode is the gain code of 0 to 7. The **gaincode** parameter is ignored when **channel** is **ALLCHAN**.

Gain Code	Voltage Range* (V)
0	0–20
1	0–10
2	0–5
3	0–4
4	0–2.5
5	0–2
6	0–1.25
7	0–1

* Applies to Prototyping Board.

RETURN VALUE

0 if successful.

-1 if address is invalid or out of range.

SEE ALSO

anaInEEWr, anaInCalib

int anaInEEWr(unsigned int channel, int opmode unsigned int gaincode);

Writes the calibration constants, gain, and offset for an input based from global tables **_adcCalibS**, **_adcCalibD**, and **_adcCalibM** to designated positions in the simulated EEPROM area of the flash memory. The constants are stored in the top 2K of the user block in a reserved memory area. Depending on the flash size, the following macros can be used to identify the starting address for these locations.

ADC_CALIB_ADDRS, address start of single-ended analog input channels

ADC_CALIB_ADDRD, address start of differential analog input channels

ADC_CALIB_ADDRM, address start of milliamp analog input channels

NOTE: This function cannot be run in RAM.

PARAMETER

channel is the analog input channel number (0 to 7) corresponding to ADC_IN0 to ADC_IN7.

opmode is the mode of operation:

SINGLE—single-ended input line
DIFF—differential input line
mAMP—milliamp input line

channel	SINGLE	DIFF	mAMP
0	+AIN0	+AIN0 -AIN1	+AIN0*
1	+AIN1	+AIN1 -AIN0*	+AIN1*
2	+AIN2	+AIN2 -AIN3	+AIN2*
3	+AIN3	+AIN3 -AIN2*	+AIN3
4	+AIN4	+AIN4 -AIN5	+AIN4
5	+AIN5	+AIN5 -AIN4*	+AIN5
6	+AIN6	+AIN6 -AIN7*	+AIN6
7	+AIN7	+AIN7 -AIN6*	+AIN7*
ALLCHAN	read all channels for selected **opmode**		

* Not accessible on Prototyping Board.

gaincode is the gain code of 0 to 7. The **gaincode** parameter is ignored when **channel** is **ALLCHAN**.

Gain Code	Voltage Range* (V)
0	0–20
1	0–10
2	0–5
3	0–4
4	0–2.5
5	0–2
6	0–1.25
7	0–1

* Applies to Prototyping Board.

RETURN VALUE

0 if successful
-1 if address is invalid or out of range.

SEE ALSO

anaInEEWr, anaInCalib

5.3 Upgrading Dynamic C

Dynamic C patches that focus on bug fixes are available from time to time. Check the Web site http://www.digi.com/support for the latest patches, workarounds, and bug fixes.

The default installation of a patch or bug fix is to install the file in a directory (folder) different from that of the original Dynamic C installation. Digi recommends using a different directory so that you can verify the operation of the patch without overwriting the existing Dynamic C installation. If you have made any changes to the BIOS or to libraries, or if you have programs in the old directory (folder), make these same changes to the BIOS or libraries in the new directory containing the patch. Do ***not*** simply copy over an entire file since you may overwrite a bug fix. Once you are sure the new patch works entirely to your satisfaction, you may retire the existing installation, but keep it available to handle legacy applications.

5.3.1 Upgrades

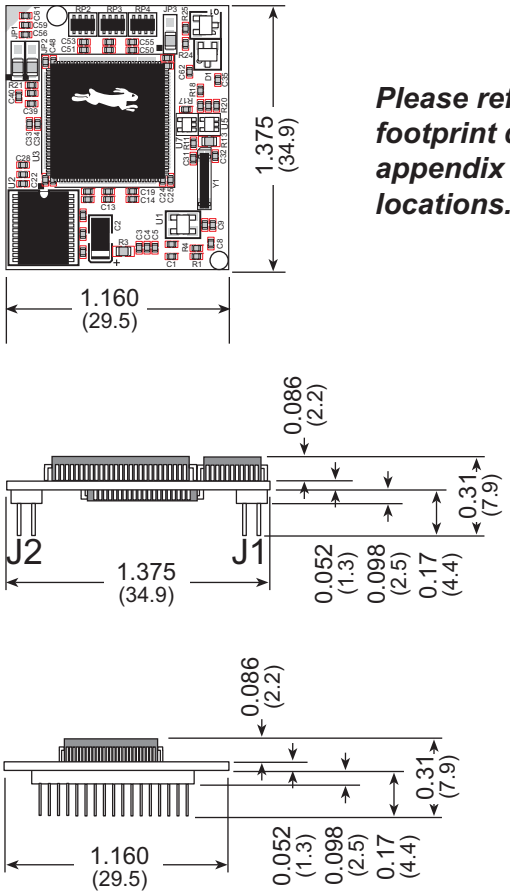
Dynamic C installations are designed for use with the board they are included with, and are included at no charge as part of our low-cost kits. Dynamic C is a complete software development system, but does not include all the Dynamic C features. Digi also offers add-on Dynamic C modules containing the popular μC/OS-II real-time operating system, as well as PPP, Advanced Encryption Standard (AES), and other select libraries. In addition to the Web-based technical support included at no extra charge, a one-year telephone-based technical support module is also available for purchase.

APPENDIX A. RCM3400 SPECIFICATIONS

Appendix A provides the specifications for the RCM3400, and describes the conformal coating.

A.1 Electrical and Mechanical Characteristics

Figure A-1 shows the mechanical dimensions for the RCM3400.



Please refer to the RCM3400 footprint diagram later in this appendix for precise header locations.

Figure A-1. RCM3400 Dimensions

It is recommended that you allow for an “exclusion zone” of 0.04" (1 mm) around the RCM3400 in all directions when the RCM3400 is incorporated into an assembly that includes other printed circuit boards. This “exclusion zone” that you keep free of other components and boards will allow for sufficient air flow, and will help to minimize any electrical or electromagnetic interference between adjacent boards. An “exclusion zone” of 0.08" (2 mm) is recommended below the RCM3400 when the RCM3400 is plugged into another assembly using the shortest connectors for headers J1 and J2. Figure A-2 shows this “exclusion zone.”

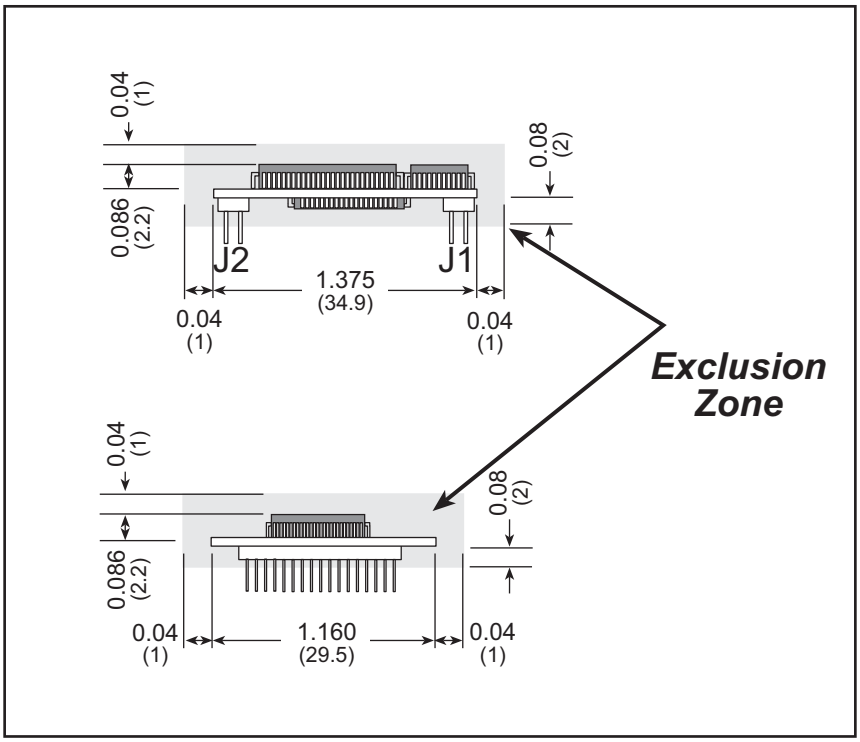


Figure A-2. RCM3400 “Exclusion Zone”

Table A-1 lists the electrical, mechanical, and environmental specifications for the RCM3400.

Table A-1. RabbitCore RCM3400 Specifications

Parameter	RCM3400	RCM3410
Microprocessor	Low-EMI Rabbit® 3000 at 29.4 MHz	
Flash Memory	512K	256K
SRAM	512K	256K
Backup Battery	Connection for user-supplied backup battery (to support RTC and SRAM)	
Analog Inputs	8 channels single-ended or 4 channels differential Programmable gain 1, 2, 4, 5, 8, 10, 16, and 20 V/V	
• A/D Converter Resolution	12 bits (11 bits single-ended)	
• A/D Conversion Time (including 120 µs raw count and Dynamic C)	180 µs	
• A/D Input Voltage Range:	0 - 2 VDC	
General-Purpose I/O	47 parallel digital I/0 lines: • 41 configurable I/O • 3 fixed inputs • 3 fixed outputs	
Additional Inputs	Startup mode (2), reset in, CONVERT	
Additional Outputs	Status, reset out, VREF	
Auxiliary I/O Bus	Can be configured for 8 data lines and 6 address lines (shared with parallel I/O lines), plus I/O read/write	
Serial Ports	5 shared high-speed, CMOS-compatible ports: • all 5 configurable as asynchronous, 3 as clocked serial (SPI), and 2 as SDLC/HDLC • 1 asynchronous serial port dedicated for programming • Support for MIR/SIR IrDA transceiver	
Serial Rate	Maximum asynchronous baud rate = CLK/8	
Slave Interface	A slave port allows the RCM3400 to be used as an intelligent peripheral device slaved to a master processor, which may either be another Rabbit 3000 or any other type of processor	
Real-Time Clock	Yes	
Timers	Ten 8-bit timers (6 cascadable), one 10-bit timer with 2 match registers	

Table A-1. RabbitCore RCM3400 Specifications (continued)

Parameter	RCM3400	RCM3410
Watchdog/Supervisor	Yes	
Pulse-Width Modulators	10-bit free-running counter and four pulse-width registers	
Input Capture	2-channel input capture can be used to time input signals from various port pins	
Quadrature Decoder	2-channel quadrature decoder accepts inputs from external incremental encoder modules	
Power	3.0–3.45 V DC @ 29.4 MHz, 2.8–3.45 V DC @ 14.7 MHz 97 mA @ 3.3 V, 29.4 MHz; 57 mA @ 3.0 V, 14.7 MHz	
Operating Temperature	–40°C to +85°C	
Humidity	5% to 95%, noncondensing	
Connectors	Two 2 × 17, 1.27 mm pitch	
Board Size	1.160" × 1.375" × 0.31" (29.5 mm ×34.9 mm × 7.9 mm)	

A.1.1 Headers

The RCM3400 uses headers at J1 and J2 for physical connection to other boards. J1 and J2 are 2 × 17 SMT headers with a 1.27 mm pin spacing.

Figure A-3 shows the layout of another board for the RCM3400 to be plugged into. These values are relative to the designated fiducial.

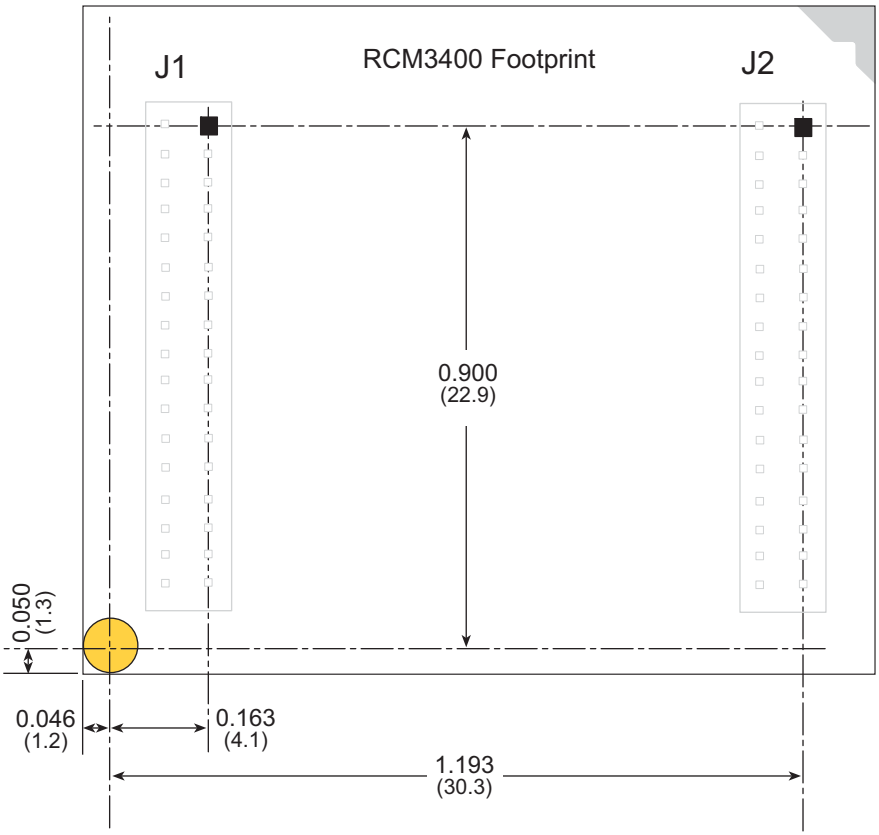


Figure A-3. User Board Footprint for RCM3400

A.2 Bus Loading

You must pay careful attention to bus loading when designing an interface to the RCM3400. This section provides bus loading information for external devices.

Table A-2 lists the capacitance for the various RCM3400 I/O ports.

Table A-2. Capacitance of Rabbit 3000 I/O Ports

I/O Ports	Input Capacitance (pF)	Output Capacitance (pF)
Parallel Ports A to G	12	14

Table A-3 lists the external capacitive bus loading for the various RCM3400 output ports. Be sure to add the loads for the devices you are using in your custom system and verify that they do not exceed the values in Table A-3.

Table A-3. External Capacitive Bus Loading -40°C to +85°C

Output Port	Clock Speed (MHz)	Maximum External Capacitive Loading (pF)
All I/O lines with clock doubler enabled	29.4	70
All I/O lines with clock doubler disabled	14.7456	100

Table A-4 lists the loadings for the A/D converter inputs.

Table A-4. A/D Converter Inputs

Parameter	Value
Input Capacitance	4–9.7 pF
Input Impedance	Common-Mode 6 MΩ Differential 7 MΩ

Figure A-4 shows a typical timing diagram for the Rabbit 3000 microprocessor external I/O read and write cycles.

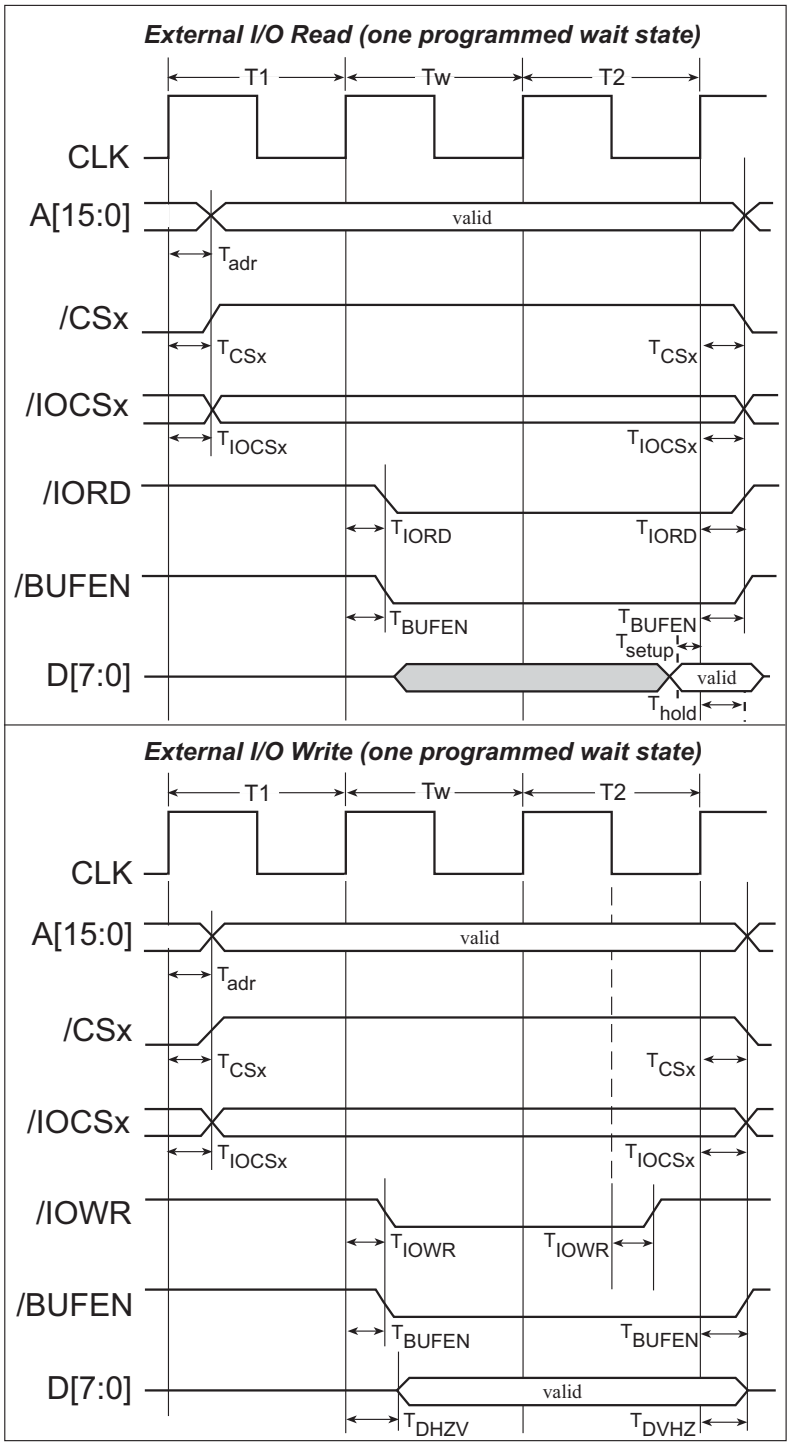


Figure A-4. External I/O Read and Write Cycles—No Extra Wait States

NOTE: **/IOCSx** can be programmed to be active low (default) or active high.

Table A-5 lists the delays in gross memory access time for several values of V_{DD}.

Table A-5. Data and Clock Delays V_{DD} ±10%, Temp, -40°C–+85°C (maximum)

VDD	Clock to Address Output Delay (ns)			Data Setup Time Delay (ns)	Spectrum Spreader Delay (ns)	
	30 pF	60 pF	90 pF		Normal dbl/no dbl	Strong dbl/no dbl
3.3	6	8	11	1	3/4.5	4.5/9
2.8	7	10	13	1.5	3.5/5.5	5.5/11

The measurements are taken at the 50% points under the following conditions.

- T = -40°C to 85°C, V = V_{DD} ±10%
- Internal clock to nonloaded CLK pin delay ≤ 1 ns @ 85°C/3.0 V

The clock to address output delays are similar, and apply to the following delays.

- T_{adr}, the clock to address delay
- T_{CSx}, the clock to memory chip select delay
- T_{IOCSx}, the clock to I/O chip select delay
- T_{IORD}, the clock to I/O read strobe delay
- T_{IOWR}, the clock to I/O write strobe delay
- T_{BUFEN}, the clock to I/O buffer enable delay

The data setup time delays are similar for both T_{setup} and T_{hold}.

When the spectrum spreader is enabled with the clock doubler, every other clock cycle is shortened (sometimes lengthened) by a maximum amount given in the table above. The shortening takes place by shortening the high part of the clock. If the doubler is not enabled, then every clock is shortened during the low part of the clock period. The maximum shortening for a pair of clocks combined is shown in the table.

Technical Note TN227, ***Interfacing External I/O with Rabbit 2000/3000 Designs***, contains suggestions for interfacing I/O devices to the Rabbit 3000 microprocessors.

A.3 Rabbit 3000 DC Characteristics

Table A-6. Rabbit 3000 Absolute Maximum Ratings

Symbol	Parameter	Maximum Rating
T_A	Operating Temperature	-55° to +85°C
T_S	Storage Temperature	-65° to +150°C
	Maximum Input Voltage: • Oscillator Buffer Input • 5-V-tolerant I/O	 V_{DD} + 0.5 V 5.5 V
V_{DD}	Maximum Operating Voltage	3.6 V

Stresses beyond those listed in Table A-6 may cause permanent damage. The ratings are stress ratings only, and functional operation of the Rabbit 3000 chip at these or any other conditions beyond those indicated in this section is not implied. Exposure to the absolute maximum rating conditions for extended periods may affect the reliability of the Rabbit 3000 chip.

Table A-7 outlines the DC characteristics for the Rabbit 3000 at 3.3 V over the recommended operating temperature range from T_A = –55°C to +85°C, V_{DD} = 3.0 V to 3.6 V.

Table A-7. 3.3 Volt DC Characteristics

Symbol	Parameter	Test Conditions	Min	Typ	Max	Units
V_{DD}	Supply Voltage		3.0	3.3	3.6	V
V_{IH}	High-Level Input Voltage		2.0			V
V_{IL}	Low-Level Input Voltage				0.8	V
V_{OH}	High-Level Output Voltage	I_{OH} = 6.8 mA, $V_{DD} = V_{DD}$ (min)	0.7 × V_{DD}			V
V_{OL}	Low-Level Output Voltage	I_{OL} = 6.8 mA, $V_{DD} = V_{DD}$ (min)			0.4	V
I_{IH}	High-Level Input Current (absolute worst case, all buffers)	$V_{IN} = V_{DD}$, $V_{DD} = V_{DD}$ (max)			10	µA
I_{IL}	Low-Level Input Current (absolute worst case, all buffers)	$V_{IN} = V_{SS}$, $V_{DD} = V_{DD}$ (max)	-10			µA
I_{OZ}	High-Impedance State Output Current (absolute worst case, all buffers)	$V_{IN} = V_{DD}$ or V_{SS}, $V_{DD} = V_{DD}$ (max), no pull-up	-10		10	µA

A.4 I/O Buffer Sourcing and Sinking Limit

Unless otherwise specified, the Rabbit I/O buffers are capable of sourcing and sinking 6.8 mA of current per pin at full AC switching speed. Full AC switching assumes a 29.4 MHz CPU clock and capacitive loading on address and data lines of less than 70 pF per pin. The absolute maximum operating voltage on all I/O is 5.5 V.

Table A-8 shows the AC and DC output drive limits of the parallel I/O buffers when the Rabbit 3000 is used in the RCM3400.

Table A-8. I/O Buffer Sourcing and Sinking Capability

Pin Name	Output Drive (Full AC Switching) Sourcing/Sinking Limits (mA)	
	Sourcing	Sinking
All data, address, and I/O lines with clock doubler enabled	6.8	6.8

Under certain conditions, the maximum instantaneous AC/DC sourcing or sinking current may be greater than the limits outlined in Table A-8. The maximum AC/DC sourcing current can be as high as 12.5 mA per buffer as long as the number of sourcing buffers does not exceed three per V_{DD} or V_{SS} pad, or up to six outputs between pads. Similarly, the maximum AC/DC sinking current can be as high as 8.5 mA per buffer as long as the number of sinking buffers does not exceed three per V_{DD} or V_{SS} pad, or up to six outputs between pads. The V_{DD} bus can handle up to 35 mA, and the V_{SS} bus can handle up to 28 mA. All these analyses were measured at 100°C.

A.5 Conformal Coating

The areas around the 32 kHz real-time clock crystal oscillator have had the Dow Corning silicone-based 1-2620 conformal coating applied. The conformally coated area is shown in Figure A-5. The conformal coating protects these high-impedance circuits from the effects of moisture and contaminants over time.

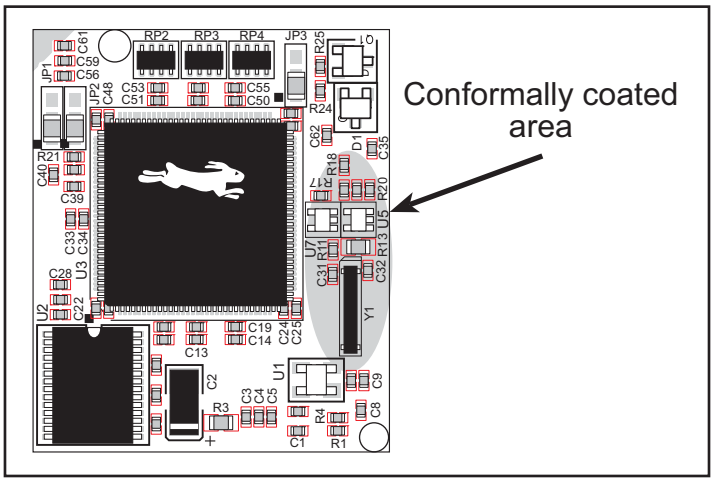


Figure A-5. RCM3400 Areas Receiving Conformal Coating

Any components in the conformally coated area may be replaced using standard soldering procedures for surface-mounted components. A new conformal coating should then be applied to offer continuing protection against the effects of moisture and contaminants.

NOTE: For more information on conformal coatings, refer to Technical Note 303, ***Conformal Coatings***.

A.6 Jumper Configurations

Figure A-6 shows the header locations used to configure the various RCM3400 options via jumpers.

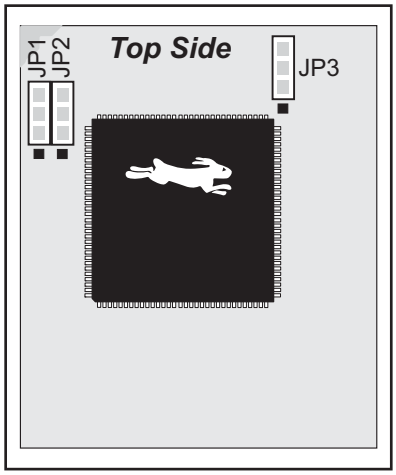


Figure A-6. Location of RCM3400 Configurable Positions

Table A-9 lists the configuration options.

Table A-9. RCM3400 Jumper Configurations

Header	Description	Pins Connected		Factory Default
JP1	Flash Memory Size	1–2	128K/256K	RCM3410
		2–3	512K	RCM3400
JP2	Flash Memory Bank Select	1–2	Normal Mode	✕
		2–3	Bank Mode	
JP3	SRAM Size	1–2	128K/256K	RCM3410
		2–3	512K	RCM3400

NOTE: The jumper connections are made using 0 Ω surface-mounted resistors.

APPENDIX B. PROTOTYPING BOARD

Appendix B describes the features and accessories of the Prototyping Board, and explains the use of the Prototyping Board to demonstrate the RCM3400 and to build prototypes of your own circuits. The RCM3400 Prototyping Board has power-supply connections and also provides some basic I/O peripherals (RS-232, RS-485, A/D converter screw-terminal header, IrDA transceiver, LEDs, and switches), as well as a prototyping area for more advanced hardware development.

B.1 Introduction

The Prototyping Board included in the Development Kit makes it easy to connect an RCM3400 module to a power supply and a PC workstation for development. It also provides some basic I/O peripherals (RS-232, RS-485, an IrDA transceiver, an Ethernet port, LEDs, and switches), as well as a prototyping area for more advanced hardware development.

For the most basic level of evaluation and development, the Prototyping Board can be used without modification.

As you progress to more sophisticated experimentation and hardware development, modifications and additions can be made to the board without modifying the RCM3400 module.

The Prototyping Board is shown below in Figure B-1, with its main features identified.

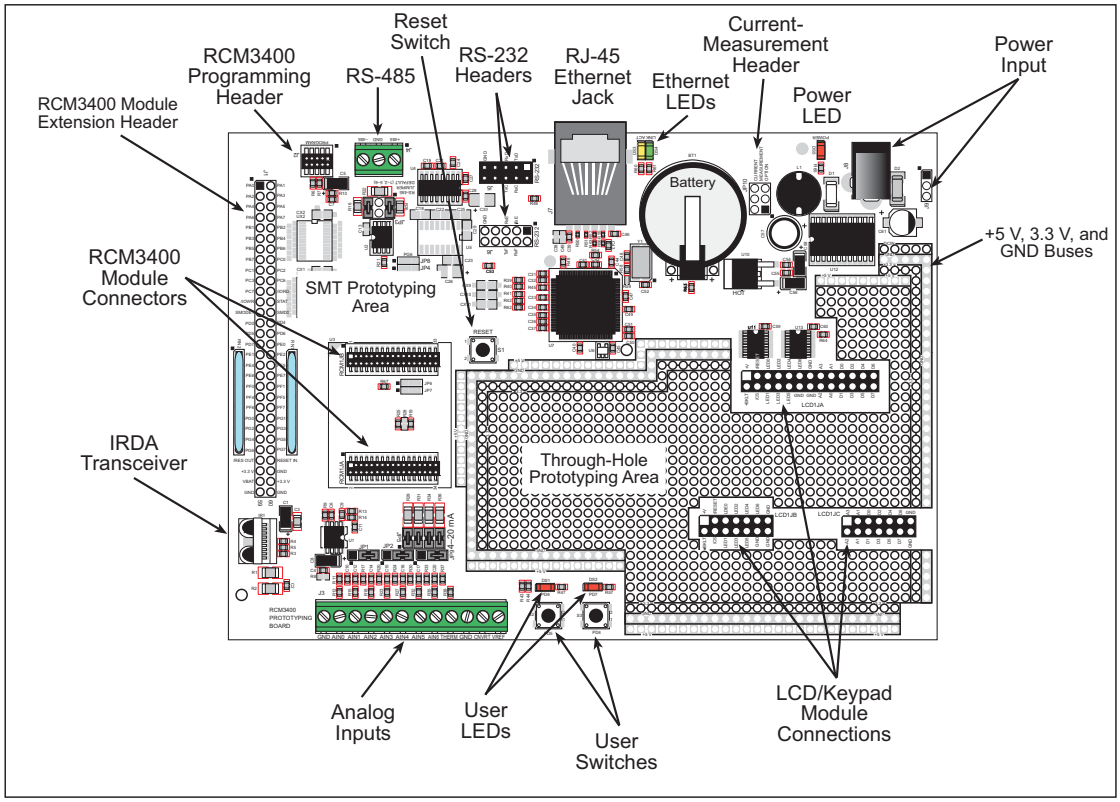


Figure B-1. Prototyping Board

B.1.1 Prototyping Board Features

- **Power Connection**—A power-supply jack and a 3-pin header are provided for connection to the power supply. Note that the 3-pin header is symmetrical, with both outer pins connected to ground and the center pin connected to the raw V+ input. The cable of the AC adapter provided with the North American version of the Development Kit is terminated with a 5.5 mm plug that connects to the power-supply jack. The header plug leading to bare leads provided for overseas customers can be connected to the 3-pin header in either orientation.

  Users providing their own power supply should ensure that it delivers 8–24 V DC at 8 W. The voltage regulators will get warm while in use.

- **Regulated Power Supply**—The raw DC voltage provided at the POWER IN jack is routed to a 5 V switching voltage regulator, then to a separate 3.3 V linear regulator. The regulators provide stable power to the RCM3400 module and the Prototyping Board.

- **Power LED**—The power LED lights whenever power is connected to the Prototyping Board.

- **Reset Switch**—A momentary-contact, normally open switch is connected directly to the RCM3400's **/RESET_IN** pin. Pressing the switch forces a hardware reset of the system.

- **Programming Header**—The programming cable is used to connect the RCM3400 via the programming header on the Prototyping Board to your PC to enable you to program your RCM3400 module.

- **I/O Switches and LEDs**—Two momentary-contact, normally open switches are connected to the PD4 and PD5 pins of the RCM3400 module and may be read as inputs by sample applications.

  Two LEDs are connected to the PD6 and PD7 pins of the RCM3400 module, and may be driven as output indicators by sample applications.

- **Prototyping Area**—A generous prototyping area has been provided for the installation of through-hole components. +3.3 V, +5 V, and Ground buses run around the edge of this area. Several areas for surface-mount devices are also available. (Note that there are SMT device pads on both top and bottom of the Prototyping Board.) Each SMT pad is connected to a hole designed to accept a 30 AWG solid wire.

- **Module Extension Headers**—The complete non-analog pin set of the RCM3400 module is duplicated at header J1. Developers can solder wires directly into the appropriate holes, or, for more flexible development, a 2 × 30 header strip with a 0.1" pitch can be soldered into place. See Figure B-4 for the header pinouts.

- **Analog Inputs Screw-Terminal Header**—The complete analog pin set of the RCM3400 module is duplicated at screw-terminal header J3. See Figure B-4 for the header pinouts.

- **Ethernet**—One 10/100Base-T Ethernet port is available on the Prototyping Board with an RJ-45 jack at J7. **LNK** and **ACT** LEDs indicate a live Ethernet link and Ethernet activity.

- **RS-232**—Two 3-wire or one 5-wire RS-232 serial ports are available on the Prototyping Board at header J5 and another two 3-wire or one 5-wire RS-232 serial ports are available at header J6.

  A 10-pin 0.1-inch spacing header strip is installed at J5 allows you to connect a ribbon cable that leads to a standard DE-9 serial connector.

  NOTE: An RS-232 driver chip needs to be installed at U5 along with a header at J6 and filtering capacitors in order to use header J6.

- **RS-485**—One RS-485 serial port is available on the Prototyping Board at screw-terminal header J4. Jumpers on header JP3 configure the termination and bias resistors.

- **Current Measurement Option**—Jumpers across pins 1–2 and 5–6 on header JP10 can be removed and replaced with an ammeter across the pins to measure the current drawn from the +5 V or the +3.3 V supplies, respectively.

- **LCD/Keypad Module**—Digi's LCD/keypad module may be plugged in directly to headers LCD1JA, LCD1JB, and LCD1JC. Appendix D provides complete information for mounting and using the LCD/keypad module.

- **IrDA**—An infrared transceiver on the Prototyping Board is capable of handling link distances up to 1.5 m. The infrared transceiver uses Serial Port F.

- **Backup Battery**—A 2032 lithium-ion battery rated at 3.0 V, 220 mA·h, provides battery backup for the RCM3400 SRAM and real-time clock.

B.2 Mechanical Dimensions and Layout

Figure B-2 shows the mechanical dimensions and layout for the RCM3400 Prototyping Board.

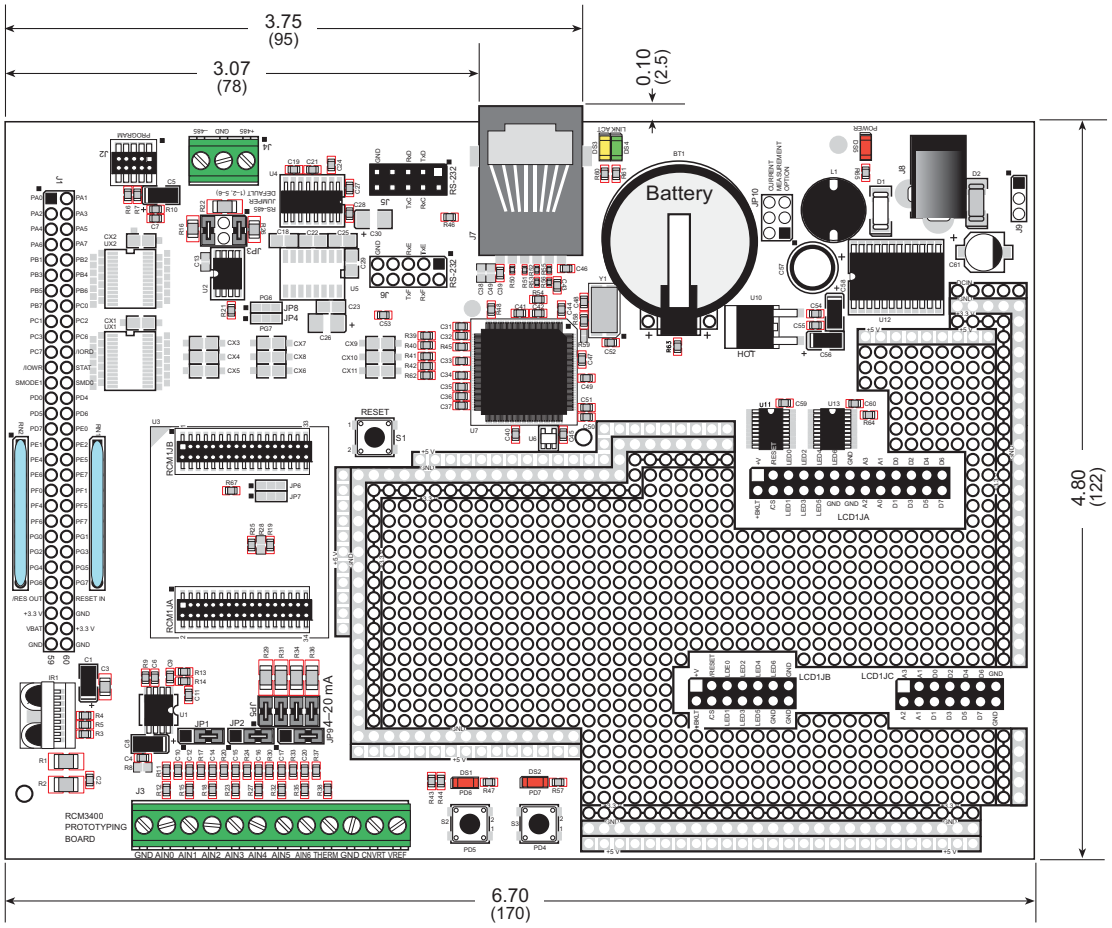


Figure B-2. Prototyping Board Dimensions

Table B-1 lists the electrical, mechanical, and environmental specifications for the Prototyping Board.

Table B-1. Prototyping Board Specifications

Parameter	Specification
Board Size	4.80" × 6.70" × 0.98" (122 mm × 170 mm × 25 mm)
Ethernet Port	10/100Base-T, RJ-45, 2 LEDs
Operating Temperature	–20°C to +60°C
Humidity	5% to 95%, noncondensing
Input Voltage	8 V to 24 V DC
Maximum Current Draw (including user-added circuits)	800 mA max. for +3.3 V supply, 1 A total +3.3 V and +5 V combined
Prototyping Area	2" × 4" (50 mm × 100 mm) throughhole, 0.1" spacing, additional space for SMT components
Connectors	Two 2 × 17 header sockets, 1.27 mm pitch, to accept RCM3400 One 2 × 5 IDC programming header, 1.27 mm pitch One 2 × 5 IDC RS-232 header, 0.1" pitch Two screw-terminal headers for RS-485 signals and analog inputs Two unstuffed header locations for RS-232 and RCM3400 signals
Standoffs/Spacers	6, accept 4-40 × ½ screws

B.3 Power Supply

The RCM3400 requires a regulated 2.8 V – 3.45 V DC power source to operate. Depending on the amount of current required by the application, different regulators can be used to supply this voltage.

The Prototyping Board has an onboard +5 V switching power regulator from which a +3.3 V linear regulator draws its supply. Thus both +5 V and +3.3 V are available on the Prototyping Board.

The Prototyping Board itself is protected against reverse polarity by a Shottky diode at D2 as shown in Figure B-3.

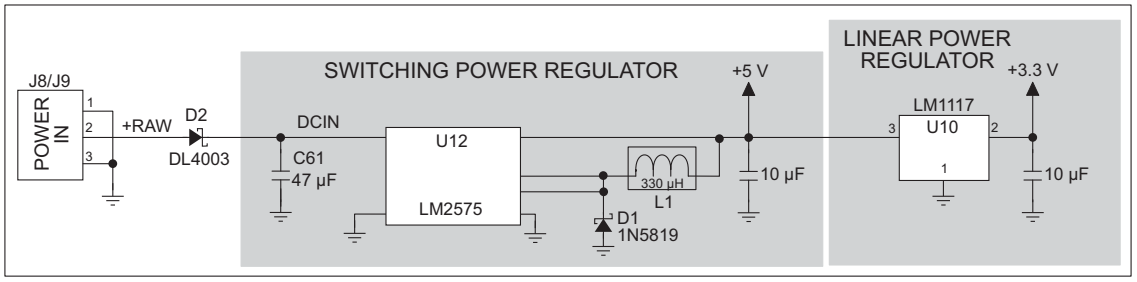


Figure B-3. Prototyping Board Power Supply

B.4 Using the Prototyping Board

The Prototyping Board is actually both a demonstration board and a prototyping board. As a demonstration board, it can be used to demonstrate the functionality of the RCM3400 right out of the box without any modifications to either board.

The Prototyping Board comes with the basic components necessary to demonstrate the operation of the RCM3400. Two LEDs (DS1 and DS2) are connected to PD6 and PD7, and two switches (S2 and S3) are connected to PD4 and PD5 to demonstrate the interface to the Rabbit 3000 microprocessor. Reset switch S1 is the hardware reset for the RCM3400.

The Prototyping Board provides the user with RCM3400 connection points brought out conveniently to labeled points at header J1 and J3 on the Prototyping Board. Although header J1 is unstuffed, a 2 × 30 header is included in the bag of parts. RS-485 signals are available on header J4, and RS-232 signals are available on header J5 (Serial Ports C and D) and header J6 (Serial Ports E and F). A header strip at J5 allows you to connect a ribbon cable, and a 2 × 5 header is included in the bag of parts for optional installation at J6. The pinouts for these locations are shown in Figure B-4.

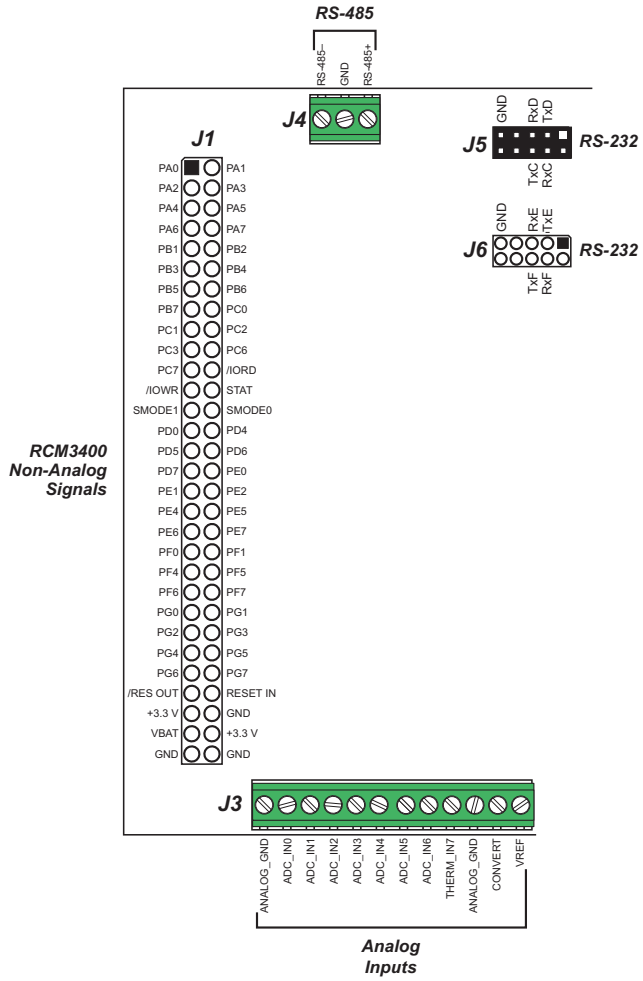


Figure B-4. Prototyping Board Pinout

Selected signals from the Rabbit 3000 microprocessor are available on header J1 of the Prototyping Board. The remaining ports on the Rabbit 3000 microprocessor are used for RS-232, RS-485, and Ethernet serial communication. Table B-2 lists the signals on header J1 and explains how they are used on the Prototyping Board.

Table B-2. Use of Rabbit 3000 Signals on RCM3400 Prototyping Board

Pin	Pin Name	Prototyping Board Use
1–8	PA0–PA7	External I/O data, ID0–ID7
9	PB1	Programming port CLKA
10–15	PB2–PB7	External I/O address, IA0–IA5
16–17	PC0–PC1	Serial Port D (RS-232, header J5)
18–19	PC2–PC3	Serial Port C (RS-232, header J5)
20–21	PC6–PC7	Serial Port A (programming port)
22	/IORD	External read strobe
23	/IOWR	External write strobe
24	STATUS	Output
25	SMODE1	Programming port
26	SMODE0	
27	PD0	RS-485 transmit enable
28	PD4	Switch S3 (normally open/pulled up)
29	PD5	Switch S2 (normally open/pulled up)
30	PD6	LED DS1 (normally high/off)
31	PD7	LED DS2 (normally high/off)
32	PE0	Ethernet
33	PE1	Input (pulled up)
34	PE2	Ethernet
35	PE4	IrDA
36	PE5	Input (pulled up)
37	PE6	External I/O strobe, LCD/keypad module
38	PE7	Input (pulled up)
39–40	PF0–PF1	Input (pulled up)
41–44	PF4–PF7	Input (pulled up)
45	PG0	Input (pulled up)
46	PG1	Ethernet
47–48	PG2–PG3	Serial Port F (RS-232/IrDA)
49–50	PG4–PG5	IrDA inputs
51–52	PG6–PG7	Serial Port E (RS-485/RS-232)
53	/RES_OUT	Reset output from Reset Generator
54	/RESET_IN	Input to Reset Generator
55	+3.3 V	
56	GND	
57	VBAT	
58	+3.3 V	
59–60	GND	

There is a 2" × 4" through-hole prototyping space available on the Prototyping Board. The holes in the prototyping area are spaced at 0.1" (2.5 mm). +3.3 V, +5 V, and GND traces run along the edge of the Prototyping Board for easy access. Small to medium circuits can be prototyped using point-to-point wiring with 20 to 30 AWG wire between the prototyping area, the +3.3 V, +5 V, and GND traces, and the surrounding area where surface-mount components may be installed. Small holes are provided around the surface-mounted components that may be installed around the prototyping area.

B.4.1 Adding Other Components

There are two sets of pads for 28-pin devices that can be used for surface-mount prototyping involving SOIC devices.There are also pads that can be used for SMT resistors and capacitors in an 0805 SMT package. Each component has every one of its pin pads connected to a hole in which a 30 AWG wire can be soldered (standard wire wrap wire can be soldered in for point-to-point wiring on the Prototyping Board). Because the traces are very thin, carefully determine which set of holes is connected to which surface-mount pad.

B.4.2 Measuring Current Draw

The Prototyping Board has a current-measurement feature available on header JP10. Normally, a jumper connects pins 1–2 and pins 5–6 on header JP10, which provide jumper connections for the +5 V and the +3.3 V regulated voltages respectively. You may remove a jumper and place an ammeter across the pins instead, as shown in the example in Figure B-5, to measure the current being drawn.

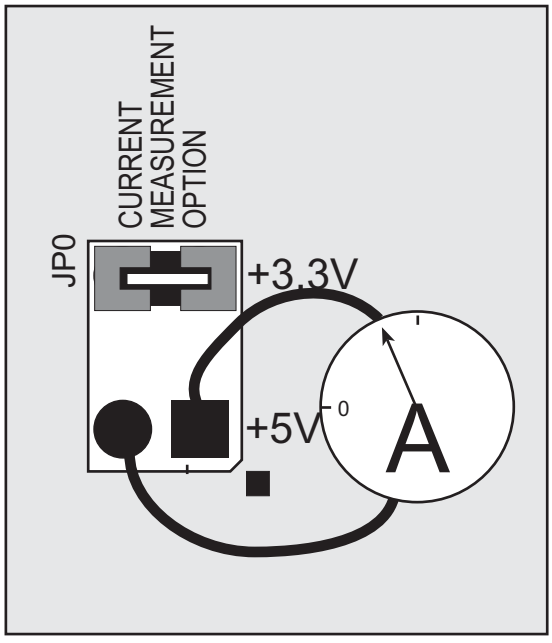


Figure B-5. Prototyping Board Current-Measurement Option

B.4.3 Analog Features

The Prototyping Board has typical support circuitry installed to complement the ADS7870 A/D converter on the RCM3400 module.

B.4.3.1 A/D Converter Inputs

Figure B-6 shows a pair of A/D converter input circuits. The resistors form an approx. 10:1 attenuator, and the capacitor filters noise pulses from the A/D converter input.

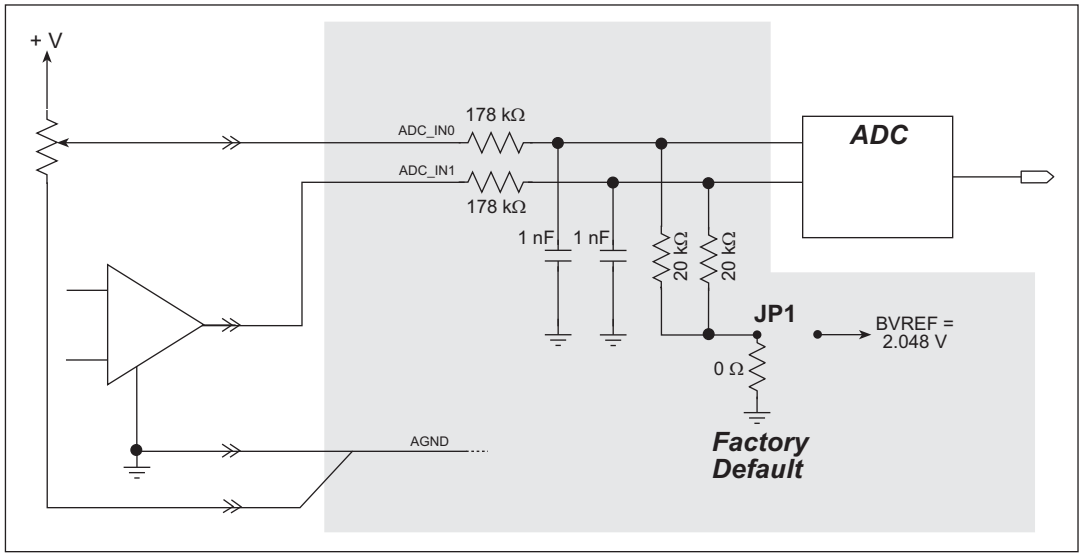


Figure B-6. A/D Converter Inputs

The A/D converter chip can make either single-ended or differential measurements depending on the value of the **opmode** parameter in the software function call. Adjacent A/D converter inputs are paired to make differential measurements. The default setup on the Prototyping Board is to measure only positive voltages for the ranges listed in Table B-3.

Table B-3. Positive A/D Converter Input Voltage Ranges

Min. Voltage (V)	Max. Voltage (V)	Amplifier Gain	mV per Tick
0.0	+20.0	1	10
0.0	+10.0	2	5
0.0	+5.0	4	2.5
0.0	+4.0	5	2.0
0.0	+2.5	8	1.25
0.0	+2.0	10	1.0
0.0	+1.25	16	0.625
0.0	+1.0	20	0.500

Many other possible ranges are possible by physically changing the resistor values that make up the attenuator circuit.

It is also possible to read a negative voltage on ADC_IN0–ADC_IN5 by moving the 0 Ω jumper (see Figure B-6) on header JP1, JP2, or JP9 associated with the A/D converter input from analog ground to the reference voltage generated and buffered by the A/D converter. Adjacent input channels are paired so that moving a particular jumper changes both of the paired channels. At the present time Digi does not offer the software drivers to work with single-ended negative voltages, but the differential mode described below may be used to measure negative voltages.

NOTE: THERM_IN7 was configured to illustrate the use of a thermistor with the sample program, and so is not available for use as a differential input. There is also no resistor attenuator for THERM_IN7, so its input voltage range is limited.

Differential measurements require two channels. As the name *differential* implies, the difference in voltage between the two adjacent channels is measured rather than the difference between the input and analog ground. Voltage measurements taken in differential mode have a resolution of 12 bits, with the 12th bit indicating whether the difference is positive or negative.

The A/D converter chip can only accept positive voltages, as explained in Section 4.4. Both differential inputs must be referenced to analog ground, and ***both inputs must be positive with respect to analog ground***. Table B-4 provides the differential voltage ranges for this setup.

Table B-4. Differential Voltage Ranges

Min. Differential Voltage (V)	Max. Differential Voltage (V)	Amplifier Gain	mV per Tick
0	±20.0	×1	10
0	±10.0	×2	5
0	±5.0	×4	2.5
0	±4.0	×5	2.0
0	±2.5	×8	1.25
0	±2.0	×10	1.00
0	±1.25	×16	0.625
0	±1.0	×20	0.500

The A/D converter inputs can also be used with 4–20 mA current sources by measuring the resulting analog voltage drop across 249 Ω 1% precision resistors placed between the analog input and analog ground for ADC_IN3 to ADC_IN6. Be sure to reconfigure the jumper positions on header JP5 as shown in Section B.5 using the slip-on jumpers included with the spare parts in the Development Kit.

B.4.3.2 Thermistor Input

Analog input THERM_IN7 on the Prototyping Board was designed specifically for use with a thermistor in conjunction with the **THERMISTOR.C** sample program, which demonstrates how to use analog input THERM_IN7 to calculate temperature for display to the Dynamic C **STDIO** window. The sample program is targeted specifically for the thermistor included with the Development Kit with R_0 @ 25°C = 3 kΩ and β 25/85 = 3965. Be sure to use the applicable R_0 and β values for your thermistor if you use another thermistor.

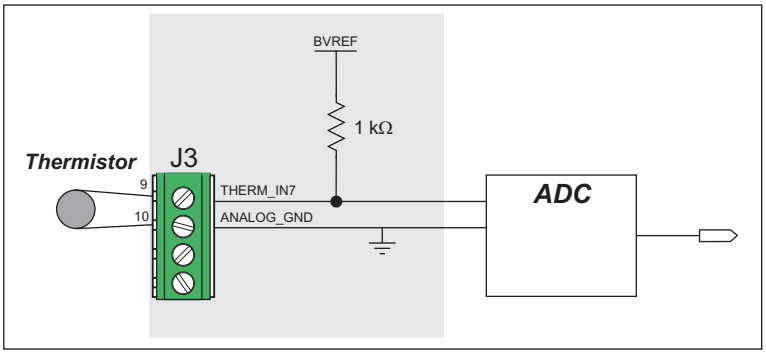


Figure B-7. Prototyping Board Thermistor Input

B.4.3.3 A/D Converter Calibration

All single-ended inputs are factory-calibrated with actual voltages at a gain code of 0. Typical values for the other gain codes and for other calibration constants for current and differential measurements are used to populate the table to allow A/D conversions to be done "out of the box." To get the best results form the A/D converter, it is necessary to calibrate each mode (single-ended, differential, and current) for each of its gains. It is imperative that you calibrate each of the A/D converter inputs in the same manner as they are to be used in the application. For example, if you will be performing floating differential measurements or differential measurements using a common analog ground, then calibrate the A/D converter in the corresponding manner. The calibration must be done with the attenuator reference selection jumper in the desired position (see Figure B-6). If a calibration is performed and the jumper is subsequently moved, the corresponding input(s) must be recalibrated. The calibration table in software only holds calibration constants based on mode, channel, and gain. ***Other factors affecting the calibration must be taken into account by calibrating using the same mode and gain setup as in the intended use.***

Sample programs are provided to illustrate how to read and calibrate the various A/D inputs for the three operating modes.

Mode	Read	Calibrate
Single-Ended, one channel	—	**AD_CAL_CHAN.C**
Single-Ended, all channels	**AD_RDVOLT_ALL.C**	**AD_CAL_ALL.C**
Milli-Amp, one channel	**AD_RDMA_CH.C**	**AD_CALMA_CH.C**
Differential, analog ground	**AD_RDDIFF_CH.C**	**AD_CALDIFF_CH.C**

These sample programs are found in the **SAMPLES\RCM3400\ADC** subdirectory. See Section 3.2.2 for more information on these sample programs and how to use them.

B.4.4 Serial Communication

The RCM3400 Prototyping Board allows you to access five of the serial ports from the RCM3400 module. Table B-5 summarizes the configuration options. Note that Serial Ports E and F can be used only with the RCM3400 Prototyping Board.

Table B-5. Prototyping Board Serial Port Configurations

Serial Port	Header	Default Use	Alternate Use
A	J2	Programming Port	RS-232
C	J5	RS-232	—
D	J5	RS-232	—
E	J4, J6	RS-485 (J4)	RS-232 (J6)
F	IrDA, J6	IrDA Transceiver	RS-232 (J6)

Serial Port E is configured in hardware for RS-232 or RS-485 via jumpers on headers JP4 and JP8 as shown in Section B.5. Serial Port F is configured in hardware for the IrDA transceiver or RS-232 via jumpers on headers JP6 and JP7 as shown in Section B.5.

B.4.4.1 RS-232

RS-232 serial communication on header J5 on both Prototyping Boards is supported by an RS-232 transceiver installed at U4. This transceiver provides the voltage output, slew rate, and input voltage immunity required to meet the RS-232 serial communication protocol. Basically, the chip translates the Rabbit 3000's signals to RS-232 signal levels. Note that the polarity is reversed in an RS-232 circuit so that a +5 V output becomes approximately -10 V and 0 V is output as +10 V. The RS-232 transceiver also provides the proper line loading for reliable communication.

A customer-supplied RS-232 transceiver may be installed at U5 on the RCM3400 Prototyping Board, and a 2 × 5 header from the bag of parts in the RCM3400 Development Kit may be installed at J6 to access Serial Ports E and F, which are by default configured for RS-485 and IrDA support on the RCM3400 Prototyping Board. Be sure to configure the 0 Ω jumpers as explained in Section B.5 to be able to access Serial Ports E and F on header J6.

RS-232 can be used effectively at the RCM3400 module's maximum baud rate for distances of up to 15 m.

RS-232 flow control on an RS-232 port is initiated in software using the **serXflowcontrolOn** function call from **RS232.LIB**, where **X** is the serial port (C or D). The locations of the flow control lines are specified using a set of five macros.

SERX_RTS_PORT—Data register for the parallel port that the RTS line is on (e.g., PCDR).

SERA_RTS_SHADOW—Shadow register for the RTS line's parallel port (e.g., PCDRShadow).

SERA_RTS_BIT—The bit number for the RTS line.

SERA_CTS_PORT—Data register for the parallel port that the CTS line is on (e.g., PCDRShadow).

SERA_CTS_BIT—The bit number for the CTS line.

Standard 3-wire RS-232 communication using Serial Ports C and D is illustrated in the following sample code.

```
#define CINBUFSIZE  15
#define COUTBUFSIZE 15

#define DINBUFSIZE  15
#define DOUTBUFSIZE 15

#ifndef _232BAUD
#define _232BAUD 115200
#endif

main(){
    serCopen(_232BAUD);
    serDopen(_232BAUD);
    serCwrFlush();
    serCrdFlush();
    serDwrFlush();
    serDrdFlush();
}
```

B.4.4.2 RS-485

The RCM3400 Prototyping Board has one RS-485 serial channel, which is connected to the Rabbit 3000 Serial Port E through an RS-485 transceiver. The half-duplex communication uses an output from PD0 on the Rabbit 3000 to control the transmit enable on the communication line. Using this scheme a strict master/slave relationship must exist between devices to insure that no two devices attempt to drive the bus simultaneously.

Serial Port E is configured in software for RS-485 as follows.

```
#define ser485open serEopen
#define ser485close serEclose
#define ser485wrFlush serEwrFlush
#define ser485rdFlush serErdFlush
#define ser485putc serEputc
#define ser485getc serEgetc

#define EINBUFSIZE  15
#define EOUTBUFSIZE 15

#ifndef _485BAUD
#define _485BAUD 115200
#endif
```

The configuration shown above is based on circular buffers. RS-485 configuration may also be done using functions from the **PACKET.LIB** library.

The RCM3400 Prototyping Boards with RCM3400 modules installed can be used in an RS-485 multidrop network spanning up to 1200 m (4000 ft), and there can be as many as 32 attached devices. Connect the 485+ to 485+ and 485– to 485– using single twisted-pair wires as shown in Figure B-8. Note that a common ground is recommended.

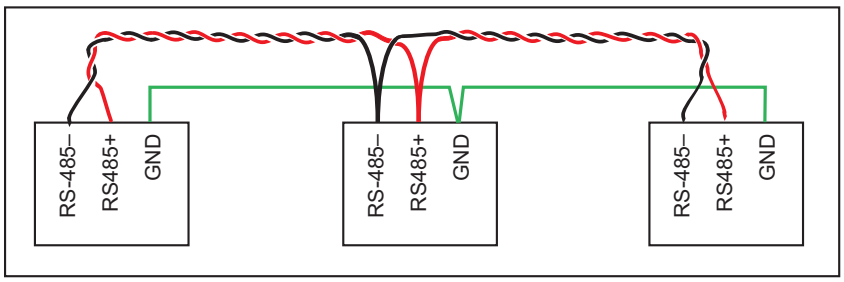


Figure B-8. RCM3400 Multidrop Network

The RCM3400 Prototyping Board comes with a 220 Ω termination resistor and two 681 Ω bias resistors installed and enabled with jumpers across pins 1–2 and 5–6 on header JP3, as shown in Figure B-9.

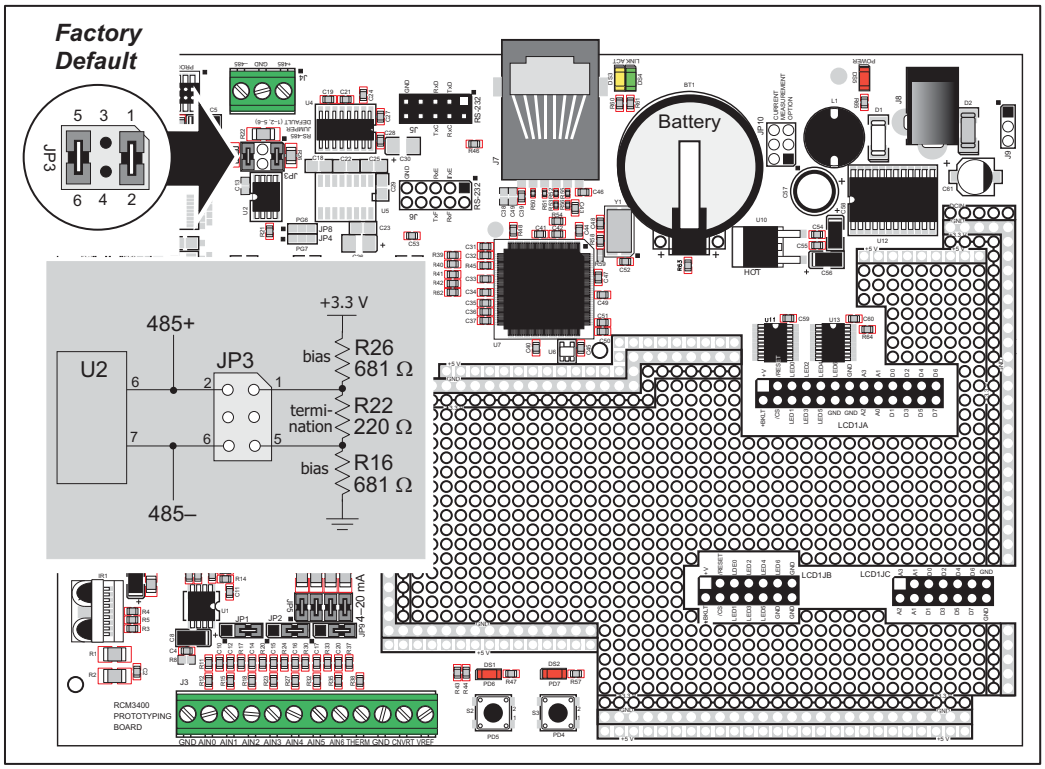


Figure B-9. RS-485 Termination and Bias Resistors

For best performance, the termination resistors in a multidrop network should be enabled only on the end nodes of the network, but ***not*** on the intervening nodes. Jumpers on boards whose termination resistors are not enabled may be stored across pins 1–3 and 4–6 of header JP3.

B.4.4.3 Ethernet Port

Figure B-10 shows the pinout for the Ethernet port (header J7). Note that there are two standards for numbering the pins on this connector—the convention used here, and numbering in reverse to that shown. Regardless of the numbering convention followed, the pin positions relative to the spring tab position (located at the bottom of the RJ-45 jack in Figure B-10) are always absolute, and the RJ-45 connector will work properly with off-the-shelf Ethernet cables.

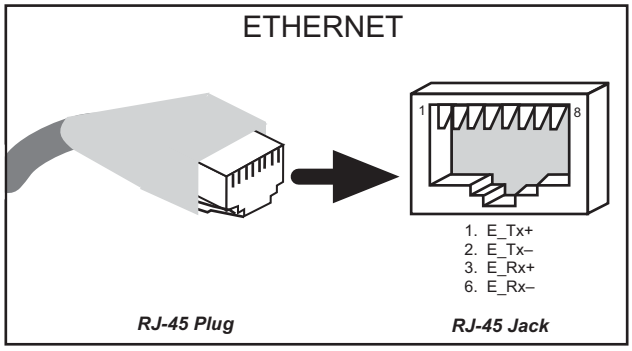


Figure B-10. RJ-45 Ethernet Port Pinout

RJ-45 pinouts are sometimes numbered opposite to the way shown in Figure B-10.

Two LEDs are placed next to the RJ-45 Ethernet jack, one to indicate a live Ethernet link (**LNK**) and one to indicate Ethernet activity (**ACT**).

The transformer/connector assembly ground is connected to the RCM3400 Prototyping Board printed circuit board digital ground via a 0 Ω resistor "jumper," R46, as shown in Figure B-11.

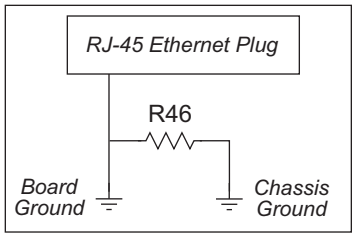


Figure B-11. Isolation Resistor R46

The factory default is for the 0 Ω resistor "jumper" at R46 to be installed. In high-noise environments, remove R46 and ground the transformer/connector assembly directly to ground by soldering a wire between the RJ-45 transformer/connector assembly and ground. This will be especially helpful to minimize ESD and/or EMI problems.

B.4.5 Other Prototyping Board Modules

An optional LCD/keypad module is available that can be mounted on the RCM3400 Prototyping Board. Refer to Appendix D, “LCD/Keypad Module,” for complete information.

B.5 RCM3400 Prototyping Board Jumper Configurations

Figure B-12 shows the header locations used to configure the various RCM3400 Prototyping Board options via jumpers.

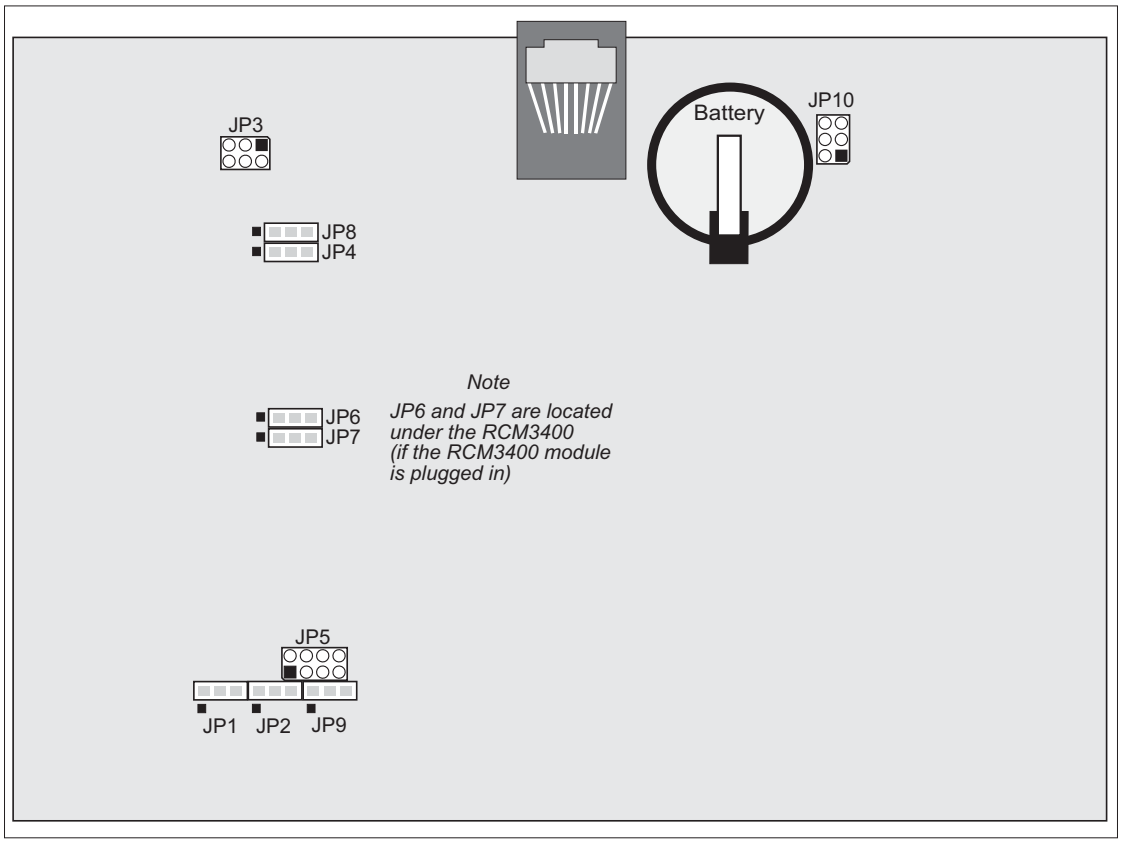


Figure B-12. Location of Configurable Jumpers on RCM3400 Prototyping Board

Table B-6 lists the configuration options using either jumpers or 0 Ω surface-mount resistors.

Table B-6. RCM3400 Prototyping Board Jumper Configurations

Header	Description	Pins Connected		Factory Default
JP1	ADC_IN0–ADC_IN1	1–2	Tied to VREF	
		2–3	Tied to analog ground	×
JP2	ADC_IN2–ADC_IN3	1–2	Tied to VREF	
		2–3	Tied to analog ground	×

Table B-6. RCM3400 Prototyping Board Jumper Configurations (continued)

Header	Description	Pins Connected		Factory Default	
JP5	Analog Voltage/4–20 mA Options	1–2	Connect for 4–20 mA option on ADC_IN3	n.c.	
		3–4	Connect for 4–20 mA option on ADC_IN4	n.c.	
		5–6	Connect for 4–20 mA option on ADC_IN5	n.c.	
		7–8	Connect for 4–20 mA option on ADC_IN6	n.c.	
JP9	ADC_IN4–ADC_IN5	1–2	Tied to VREF		
		2–3	Tied to analog ground	✕	
JP10	Current Measurement Option	1–2	+5 V	Connected	
		5–6	+ 3.3 V	Connected	
JP3	RS-485 Bias and Termination Resistors	1–2 5–6	Bias and termination resistors connected	✕	Available only on RCM3400 Prototyping Board
		1–3 4–6	Bias and termination resistors ***not*** connected (parking position for jumpers)		
JP4*	PG7 RS-232/RS-485 Select	1–2	RS-485	✕	
		2–3	RS-232 (RxE)		
JP6*	PG3 IrDA/RS-232 Select	1–2	IrDA	✕	
		2–3	RS-232 (RxF)		
JP7*	PG2 IrDA/RS-232 Select	1–2	IrDA	✕	
		2–3	RS-232 (TxF)		
JP8*	PG6 RS-232/RS-485 Select	1–2	RS-485	✕	
		2–3	RS-232 (TxE)		

* These jumper connections are made using 0 Ω surface-mounted resistors.

APPENDIX C. USING THE TCP/IP FEATURES

C.1 TCP/IP Connections

Programming and development can be done with the RCM3400 modules without connecting the Ethernet port on the RCM3400 Prototyping Board to a network. However, if you will be running the sample programs that use the Ethernet capability or will be doing Ethernet-enabled development, you should connect the RCM3400 Prototyping Board's Ethernet port at this time.

Before proceeding you will need to have the following items.

- If you don't have Ethernet access, you will need at least a 10Base-T Ethernet card (available from your favorite computer supplier) installed in a PC.
- Two RJ-45 straight through Ethernet cables and a hub, or an RJ-45 crossover Ethernet cable.

The Ethernet cables and a 10Base-T Ethernet hub are available from Rabbit Semiconductor in a TCP/IP tool kit. More information is available at http://www.digi.com/support.

1. Connect the AC adapter and the programming cable as shown in Chapter 2, "Getting Started."
2. Ethernet Connections

   There are four options for connecting the RCM3400 Prototyping Board to a network for development and runtime purposes. The first two options permit total freedom of action in selecting network addresses and use of the "network," as no action can interfere with other users. We recommend one of these options for initial development.

- **No LAN —** The simplest alternative for desktop development. Connect the RCM3400 Prototyping Board's Ethernet port directly to the PC's network interface card using an RJ-45 *crossover cable*. A crossover cable is a special cable that flips some connections between the two connectors and permits direct connection of two client systems. A standard RJ-45 network cable will not work for this purpose.
- **Micro-LAN —** Another simple alternative for desktop development. Use a small Ethernet 10Base-T hub and connect both the PC's network interface card and the RCM3400 Prototyping Board's Ethernet port to it using standard network cables.

The following options require more care in address selection and testing actions, as conflicts with other users, servers and systems can occur:

- **LAN —** Connect the RCM3400 Prototyping Board's Ethernet port to an existing LAN, preferably one to which the development PC is already connected. You will need to obtain IP addressing information from your network administrator.
- **WAN —** The RCM3400 is capable of direct connection to the Internet and other Wide Area Networks through the Prototyping Board, but exceptional care should be used with IP address settings and all network-related programming and development. We recommend that development and debugging be done on a local network before connecting a RabbitCore system to the Internet.

  TIP: Checking and debugging the initial setup on a micro-LAN is recommended before connecting the system to a LAN or WAN.

The PC running Dynamic C through the serial port on the RCM3400 Prototyping Board does not need to be the PC with the Ethernet card.

3. Apply Power

   Plug in the AC adapter. The RCM3400 module and Prototyping Board are now ready to be used.

C.2 TCP/IP Primer on IP Addresses

Obtaining IP addresses to interact over an existing, operating, network can involve a number of complications, and must usually be done with cooperation from your ISP and/or network systems administrator. For this reason, it is suggested that the user begin instead by using a direct connection between a PC and the RCM3400 using an Ethernet crossover cable or a simple arrangement with a hub. (A crossover cable should not be confused with regular straight through cables.)

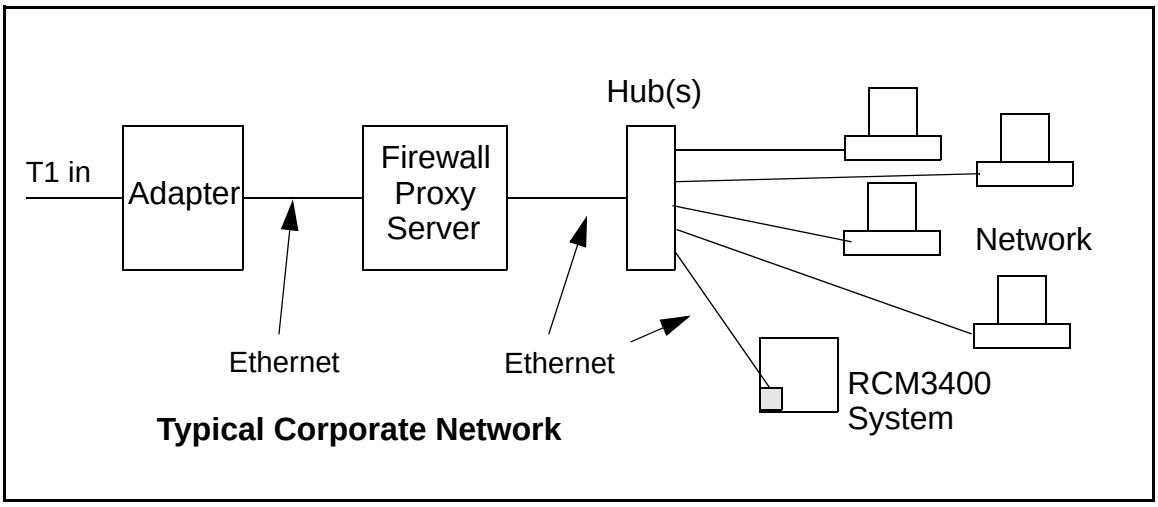
In order to set up this direct connection, the user will have to use a PC without networking, or disconnect a PC from the corporate network, or install a second Ethernet adapter and set up a separate private network attached to the second Ethernet adapter. Disconnecting your PC from the corporate network may be easy or nearly impossible, depending on how it is set up. If your PC boots from the network or is dependent on the network for some or all of its disks, then it probably should not be disconnected. If a second Ethernet adapter is used, be aware that Windows TCP/IP will send messages to one adapter or the other, depending on the IP address and the binding order in Microsoft products. Thus you should have different ranges of IP addresses on your private network from those used on the corporate network. If both networks service the same IP address, then Windows may send a packet intended for your private network to the corporate network. A similar situation will take place if you use a dial-up line to send a packet to the Internet. Windows may try to send it via the local Ethernet network if it is also valid for that network.

The following IP addresses are set aside for local networks and are not allowed on the Internet: 10.0.0.0 to 10.255.255.255, 172.16.0.0 to 172.31.255.255, and 192.168.0.0 to 192.168.255.255.

The RCM3400 Prototyping Board uses a 10Base-T type of Ethernet connection, which is the most common scheme. The RJ-45 connectors are similar to U.S. style telephone connectors, except they are larger and have 8 contacts.

An alternative to the direct connection using a crossover cable is a direct connection using a hub. The hub relays packets received on any port to all of the ports on the hub. Hubs are low in cost and are readily available. The RCM3400 Prototyping Board uses 10 Mbps Ethernet, so the hub or Ethernet adapter must be either a 10 Mbps unit or a 10/100 unit that adapts to 10 Mbps.

In a corporate setting where the Internet is brought in via a high-speed line, there are typically machines between the outside Internet and the internal network. These machines include a combination of proxy servers and firewalls that filter and multiplex Internet traffic. In the configuration below, the RCM3400 Prototyping Board could be given a fixed address so any of the computers on the local network would be able to contact it. It may be possible to configure the firewall or proxy server to allow hosts on the Internet to directly contact the controller, but it would probably be easier to place the controller directly on the external network outside of the firewall. This avoids some configuration complications by sacrificing some security.



Typical Corporate Network

If your system administrator can give you an Ethernet cable along with its IP address, the netmask and the gateway address, then you may be able to run the sample programs without having to setup a direct connection between your computer and the RCM3400. You will also need the IP address of the nameserver, the name or IP address of your mail server, and your domain name for some of the sample programs.

C.2.1 IP Addresses Explained

IP (Internet Protocol) addresses are expressed as 4 decimal numbers separated by periods, for example:

216.103.126.155

10.1.1.6

Each decimal number must be between 0 and 255. The total IP address is a 32-bit number consisting of the 4 bytes expressed as shown above. A local network uses a group of adjacent IP addresses. There are always 2^N IP addresses in a local network. The netmask (also called subnet mask) determines how many IP addresses belong to the local network. The netmask is also a 32-bit address expressed in the same form as the IP address. An example netmask is:

255.255.255.0

This netmask has 8 zero bits in the least significant portion, and this means that 2^8 addresses are a part of the local network. Applied to the IP address above (216.103.126.155), this netmask would indicate that the following IP addresses belong to the local network:

216.103.126.0

216.103.126.1

216.103.126.2

etc.

216.103.126.254

216.103.126.255

The lowest and highest address are reserved for special purposes. The lowest address (216.103.126.0) is used to identify the local network. The highest address (216.103.126.255) is used as a broadcast address. Usually one other address is used for the address of the gateway out of the network. This leaves 256 - 3 = 253 available IP addresses for the example given.

C.2.2 How IP Addresses are Used

The actual hardware connection via an Ethernet uses Ethernet adapter addresses (also called MAC addresses). These are 48-bit addresses and are unique for every Ethernet adapter manufactured. In order to send a packet to another computer, given the IP address of the other computer, it is first determined if the packet needs to be sent directly to the other computer or to the gateway. In either case, there is an IP address on the local network to which the packet must be sent. A table is maintained to allow the protocol driver to determine the MAC address corresponding to a particular IP address. If the table is empty, the MAC address is determined by sending an Ethernet broadcast packet to all devices on the local network asking the device with the desired IP address to answer with its MAC address. In this way, the table entry can be filled in. If no device answers, then the device is nonexistent or inoperative, and the packet cannot be sent.

IP addresses are arbitrary and can be allocated as desired provided that they don't conflict with other IP addresses. However, if they are to be used with the Internet, then they must be numbers that are assigned to your connection by proper authorities, generally by delegation via your service provider.

Each RCM3400 RabbitCore module has its own unique MAC address, which consists of the prefix 0090C2 followed by a code that is unique to each RCM3400 module. For example, a MAC address might be 0090C2C002C0.

> **TIP:** You can always obtain the MAC address on your board by running the sample program **DISPLAY_MAC.C** from the **SAMPLES\TCPIP** folder.

C.2.3 Dynamically Assigned Internet Addresses

In many instances, there are no fixed IP addresses. This is the case when, for example, you are assigned an IP address dynamically by your dial-up Internet service provider (ISP) or when you have a device that provides your IP addresses using the Dynamic Host Configuration Protocol (DHCP). The RCM3400 modules can use such IP addresses to send and receive packets on the Internet, but you must take into account that this IP address may only be valid for the duration of the call or for a period of time, and could be a private IP address that is not directly accessible to others on the Internet. These private address can be used to perform some Internet tasks such as sending e-mail or browsing the Web, but usually cannot be used to participate in conversations that originate elsewhere on the Internet. If you want to find out this dynamically assigned IP address, under Windows 98 you can run the **winipcfg** program while you are connected and look at the interface used to connect to the Internet.

Many networks use private IP addresses that are assigned using DHCP. When your computer comes up, and periodically after that, it requests its networking information from a DHCP server. The DHCP server may try to give you the same address each time, but a fixed IP address is usually not guaranteed.

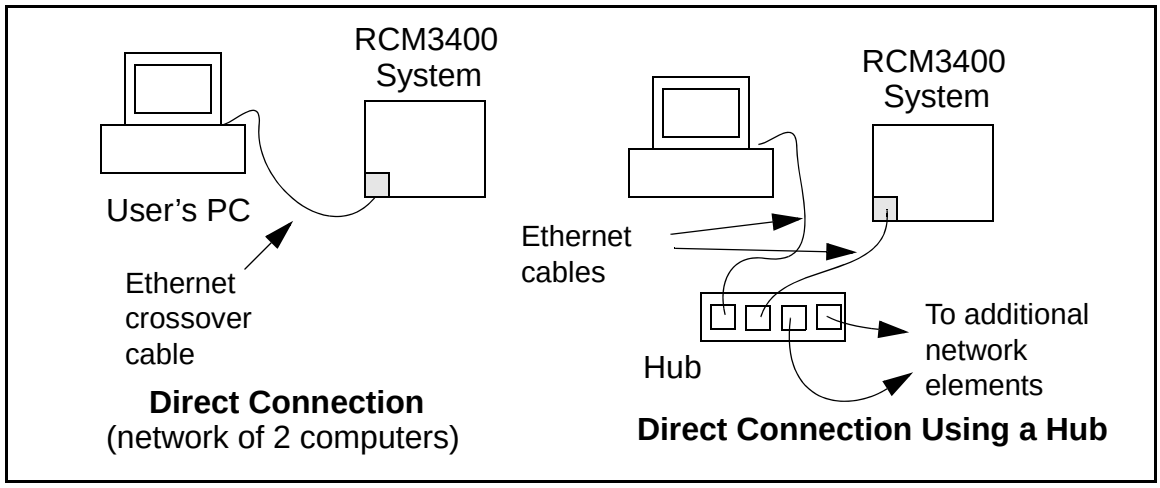
If you are not concerned about accessing the RCM3400 from the Internet, you can place the RCM3400 on the internal network using a private address assigned either statically or through DHCP.

C.3 Placing Your Device on the Network

In many corporate settings, users are isolated from the Internet by a firewall and/or a proxy server. These devices attempt to secure the company from unauthorized network traffic, and usually work by disallowing traffic that did not originate from inside the network. If you want users on the Internet to communicate with your RCM3400, you have several options. You can either place the RCM3400 directly on the Internet with a real Internet address or place it behind the firewall. If you place the RCM3400 behind the firewall, you need to configure the firewall to translate and forward packets from the Internet to the RCM3400.

C.4 Running TCP/IP Sample Programs

We have provided a number of sample programs demonstrating various uses of TCP/IP for networking embedded systems. These programs require you to connect your PC and the RCM3400 board together on the same network. This network can be a local private network (preferred for initial experimentation and debugging), or a connection via the Internet.



C.4.1 How to Set IP Addresses in the Sample Programs

With the introduction of Dynamic C 7.30 we have taken steps to make it easier to run many of our sample programs. You will see a **TCPCONFIG** macro. This macro tells Dynamic C to select your configuration from a list of default configurations. You will have three choices when you encounter a sample program with the **TCPCONFIG** macro.

1. You can replace the **TCPCONFIG** macro with individual **MY_IP_ADDRESS**, **MY_NETMASK**, **MY_GATEWAY**, and **MY_NAMESERVER** macros in each program.
2. You can leave **TCPCONFIG** at the usual default of 1, which will set the IP configurations to **10.10.6.100**, the netmask to **255.255.255.0**, and the nameserver and gateway to **10.10.6.1**. If you would like to change the default values, for example, to use an IP address of **10.1.1.2** for the RCM3400 board, and **10.1.1.1** for your PC, you can edit the values in the section that directly follows the "General Configuration" comment in the **TCP_CONFIG.LIB** library. You will find this library in the **LIB\TCPIP** directory.
3. You can create a **CUSTOM_CONFIG.LIB** library and use a **TCPCONFIG** value greater than 100. Instructions for doing this are at the beginning of the **TCP_CONFIG.LIB** library in the **LIB\TCPIP** directory.

There are some other "standard" configurations for **TCPCONFIG** that let you select different features such as DHCP. Their values are documented at the top of the **TCP_CONFIG.LIB** library in the **LIB\TCPIP** directory. More information is available in the ***Dynamic C TCP/IP User's Manual***.

IP Addresses Before Dynamic C 7.30

Most of the sample programs use macros to define the IP address assigned to the board and the IP address of the gateway, if there is a gateway. Instead of the **TCPCONFIG** macro, you will see a **MY_IP_ADDRESS** macro and other macros.

```
#define MY_IP_ADDRESS "10.10.6.170"
#define MY_NETMASK "255.255.255.0"
#define MY_GATEWAY "10.10.6.1"
#define MY_NAMESERVER "10.10.6.1"
```

In order to do a direct connection, the following IP addresses can be used for the RCM3400:

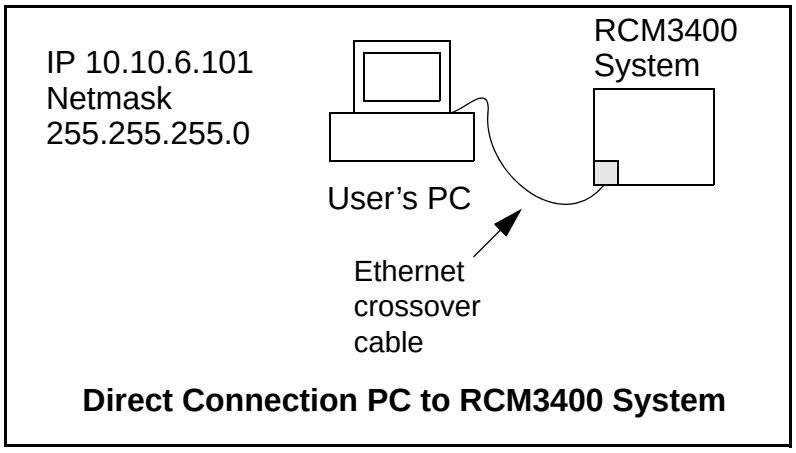
```
#define MY_IP_ADDRESS "10.1.1.2"
#define MY_NETMASK "255.255.255.0"
// #define MY_GATEWAY "10.10.6.1"
// #define MY_NAMESERVER "10.10.6.1"
```

In this case, the gateway and nameserver are not used, and are commented out. The IP address of the board is defined to be **10.1.1.2**. The IP address of your PC can be defined as **10.1.1.1**.

C.4.2 How to Set Up your Computer's IP Address for Direct Connect

When your computer is connected directly to the RCM3400 Prototyping Board via an Ethernet connection, you need to assign an IP address to your computer. To assign the PC the address **10.10.6.101** with the netmask **255.255.255.0**, do the following.

Click on **Start > Settings > Control Panel** to bring up the Control Panel, and then double-click the Network icon. Depending on which version of Windows you are using, look for the **TCP/IP Protocol**/**Network > Dial-Up Connections**/**Network** line or tab. Double-click on this line or select **Properties** or **Local Area Connection > Properties** to bring up the TCP/IP properties dialog box. You can edit the IP address and the subnet mask directly. (Disable "obtain an IP address automatically".) You may want to write down the existing values in case you have to restore them later. It is not necessary to edit the gateway address since the gateway is not used with direct connect.



Direct Connection PC to RCM3400 System

C.5 Run the PINGME.C Sample Program

Connect the crossover cable from your computer's Ethernet port to the RJ-45 Ethernet connector on the RCM3400 Prototyping Board. Open this sample program from the **SAMPLES\TCPIP\ICMP** folder, compile the program, and start it running under Dynamic C. When the program starts running, the green **LNK** light on the RCM3400 Prototyping Board should be on to indicate an Ethernet connection is made. (Note: If the **LNK** light does not light, you may not have a crossover cable, or if you are using a hub perhaps the power is off on the hub.)

The next step is to ping the board from your PC. This can be done by bringing up the MS-DOS window and running the pingme program:

```
ping 10.10.6.100
```

or by **Start > Run**

and typing the entry

```
ping 10.10.6.100
```

Notice that the red **ACT** light flashes on the RCM3400 Prototyping Board while the ping is taking place, and indicates the transfer of data. The ping routine will ping the board four times and write a summary message on the screen describing the operation.

C.6 Running Additional Sample Programs With Direct Connect

The sample programs discussed here are in the Dynamic C **SAMPLES\RCM3400\TCPIP** folder.

- **BROWSELED.C**—This program demonstrates a basic controller running a Web page. Two "LEDs" are created on the Web page, and two buttons on the Prototyping Board then toggle them. Users can change the status of the lights from the Web browser. The LEDs on the Prototyping Board match the ones on the Web page. As long as you have not modified the **TCPCONFIG 1** macro in the sample program, enter the following server address in your Web browser to bring up the Web page served by the sample program.

  http://10.10.6.100

  Otherwise use the TCP/IP settings you entered in the **TCP_CONFIG.LIB** library.

- **MBOXDEMO.C**—Implements a Web server that allows e-mail messages to be entered and then shown on the LCD/keypad module.

- **PINGLED.C**—This program demonstrates ICMP by pinging a remote host. It will flash LEDs DS1 and DS2 on the Prototyping Board when a ping is sent and received.

- **SMTP.C**—This program allows you to send an E-mail when a switch on the Prototyping Board is pressed. Follow the instructions included with the sample program.

C.7 Where Do I Go From Here?

NOTE: If you purchased your RCM3400 through a distributor or through a Rabbit Semiconductor partner, contact the distributor or partner first for technical support.

If there are any problems at this point:

- Use the Dynamic C **Help** menu to get further assistance with Dynamic C.
- Check the Rabbit Semiconductor Technical Bulletin Board at http://forums.digi.com/support/formum/index..
- Use the Technical Support e-mail form at http://www.digi.com/support.

If the sample programs ran fine, you are now ready to go on.

Additional sample programs are described in the ***Dynamic C TCP/IP User's Manual***.

Please refer to the ***Dynamic C TCP/IP User's Manual*** to develop your own applications. ***An Introduction to TCP/IP*** provides background information on TCP/IP, and is available on the CD and on our Web site.

APPENDIX D. LCD/KEYPAD MODULE

An optional LCD/keypad is available for the Prototyping Board. Appendix D describes the LCD/keypad and provides the software function calls to make full use of the LCD/keypad.

D.1 Specifications

Two optional LCD/keypad modules—with or without a panel-mounted NEMA 4 water-resistant bezel—are available for use with the RCM3400 Prototyping Board. They are shown in Figure D-1.

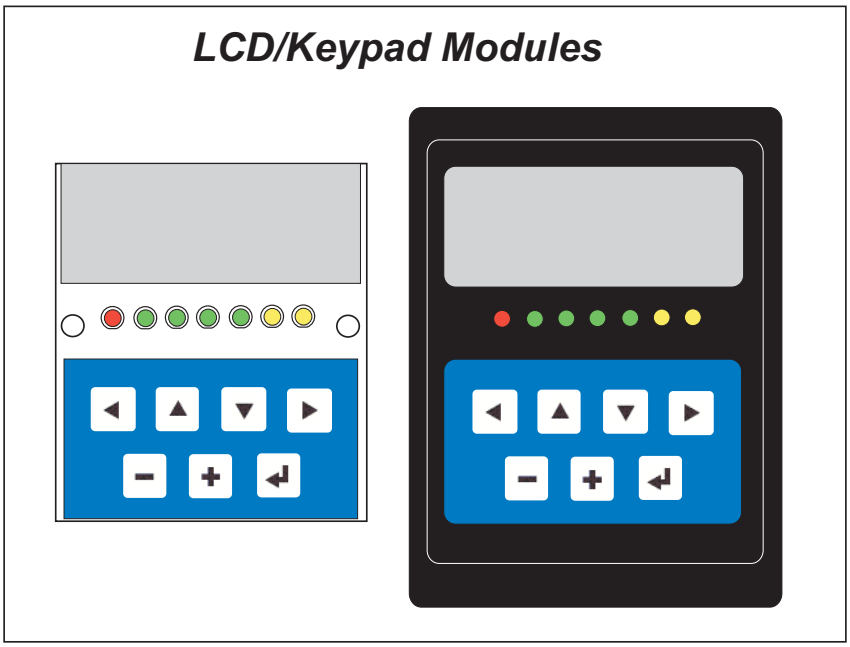


Figure D-1. LCD/Keypad Module Versions

Only the version without the bezel can mount directly on the Prototyping Board; if you have the version with a bezel, you will have to remove the bezel to be able to mount the LCD/keypad module on the Prototyping Board. Either version of the LCD/keypad module can be installed at a remote location up to 60 cm (24") away. Contact your sales representative or your authorized Digi distributor for further assistance in purchasing an LCD/keypad module.

Mounting hardware and a 60 cm (24") extension cable are also available for the LCD/keypad module through your sales representative or authorized distributor.

Table D-1 lists the electrical, mechanical, and environmental specifications for the LCD/keypad module.

Table D-1. LCD/Keypad Specifications

Parameter	Specification
Board Size	2.60" × 3.00" × 0.75" (66 mm × 76 mm × 19 mm)
Bezel Size	4.50" × 3.60" × 0.30" (114 mm × 91 mm × 7.6 mm)
Temperature	Operating Range: 0°C to +50°C Storage Range: –40°C to +85°C
Humidity	5% to 95%, noncondensing
Power Consumption	1.5 W maximum*
Connections	Connects to high-rise header sockets on the Prototyping Board
LCD Panel Size	122 × 32 graphic display
Keypad	7-key keypad
LEDs	Seven user-programmable LEDs

* The backlight adds approximately 650 mW to the power consumption.

The LCD/keypad module has 0.1" IDC headers at J1, J2, and J3 for physical connection to other boards or ribbon cables. Figure D-2 shows the LCD/keypad module footprint. These values are relative to one of the mounting holes.

NOTE: All measurements are in inches followed by millimeters enclosed in parentheses. All dimensions have a manufacturing tolerance of ±0.01" (0.25 mm).

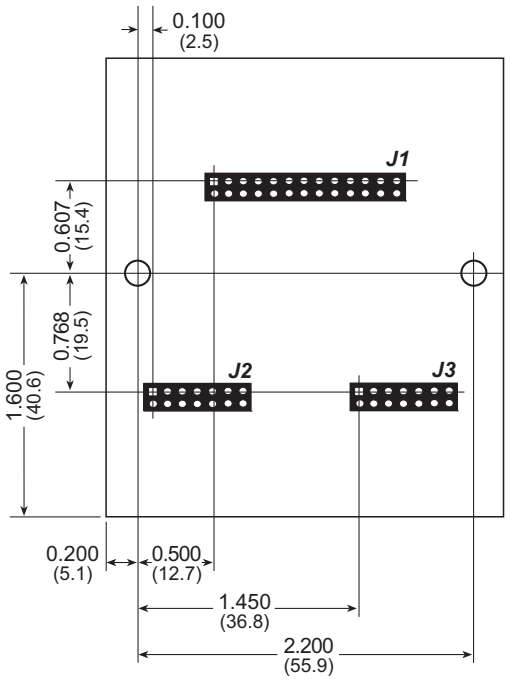


Figure D-2. Mother Board Footprint for LCD/Keypad Module

D.2 Contrast Adjustments for All Boards

Starting in 2005, LCD/keypad modules were factory-configured to optimize their contrast based on the voltage of the system they would be used in. Be sure to select a KDU3V LCD/keypad module for use with the RCM3400 Prototyping Board — these modules operate at 3.3 V. You may adjust the contrast using the potentiometer at R2 as shown in Figure D-3. LCD/keypad modules configured for 5 V may be used with the 3.3 V RCM3400 Prototyping Board, but the backlight will be dim.

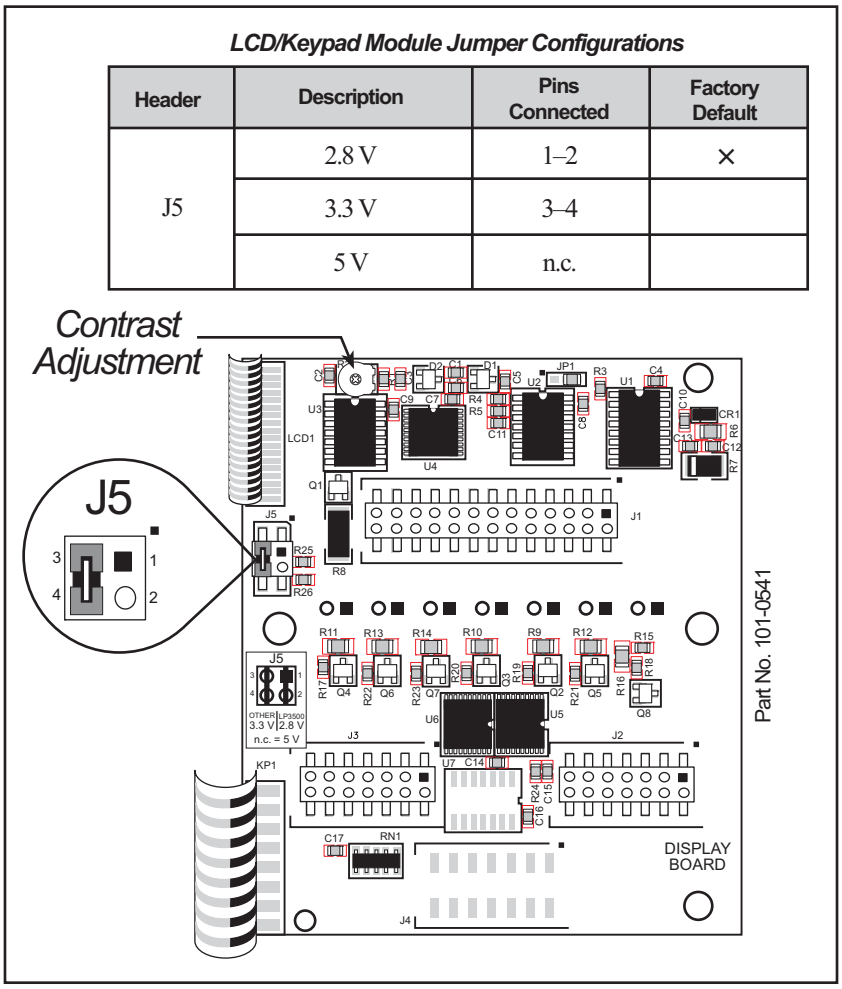


Figure D-3. LCD/Keypad Module Voltage Settings

You can set the contrast on the LCD display of pre-2005 LCD/keypad modules by adjusting the potentiometer at R2 or by setting the voltage for 3.3 V by connecting the jumper across pins 3–4 on header J5 as shown in Figure D-3. Only one of these two options is available on these LCD/keypad modules.

NOTE: Older LCD/keypad modules that do not have a header at J5 or a contrast adjustment potentiometer at R2 are limited to operate only at 5 V, and will not work with the RCM3400 Prototyping Board. The older LCD/keypad modules are no longer being sold.

D.3 Keypad Labeling

The keypad may be labeled according to your needs. A template is provided in Figure D-4 to allow you to design your own keypad label insert.

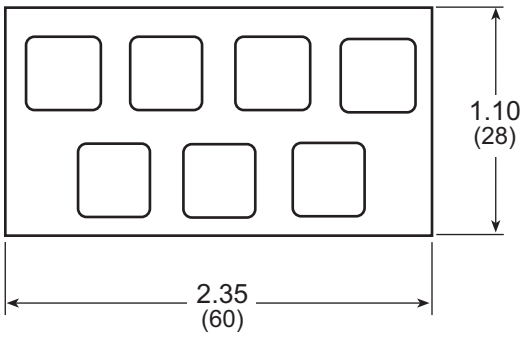


Figure D-4. Keypad Template

To replace the keypad legend, remove the old legend and insert your new legend prepared according to the template in Figure D-4. The keypad legend is located under the blue keypad matte, and is accessible from the left only as shown in Figure D-5.

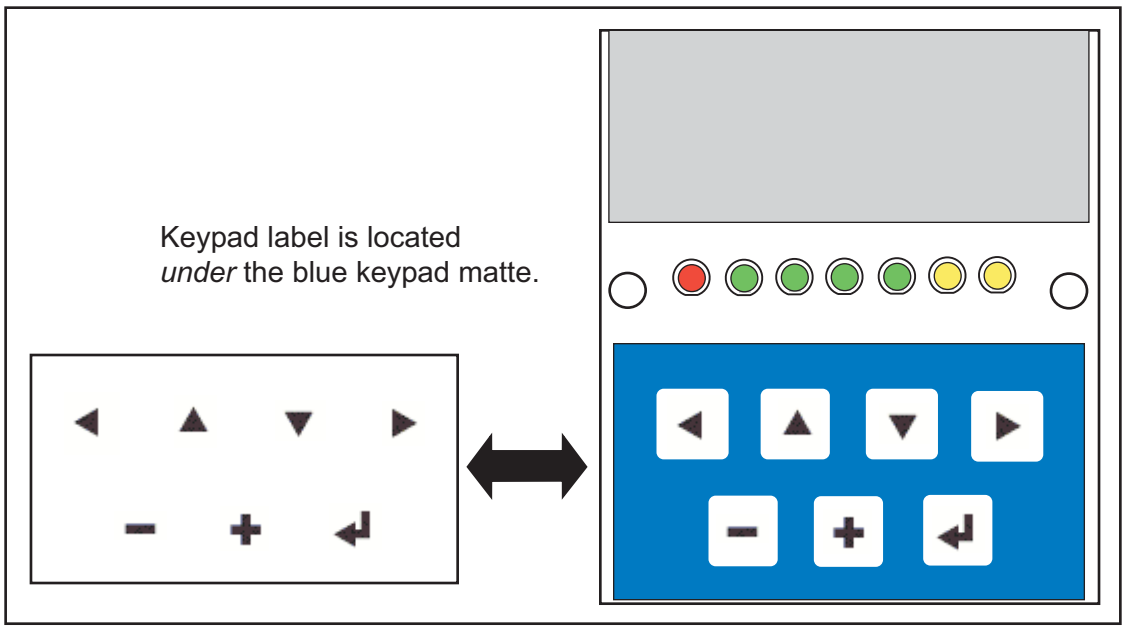


Figure D-5. Removing and Inserting Keypad Label

The sample program **KEYBASIC.C** in the **122x32_1x7** folder in **SAMPLES\LCD_KEYPAD** shows how to reconfigure the keypad for different applications.

D.4 Header Pinouts

Figure D-6 shows the pinouts for the LCD/keypad module.

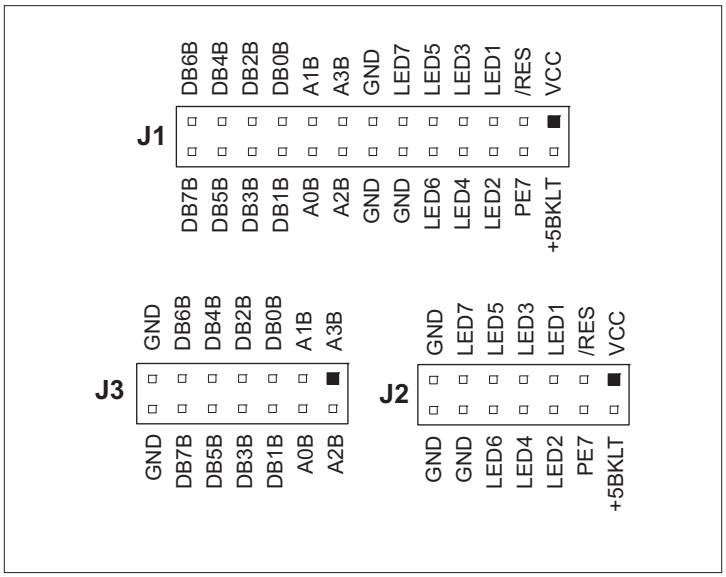

J1
DB6B DB4B DB2B DB0B A1B A3B GND LED7 LED5 LED3 LED1 /RES VCC
DB7B DB5B DB3B DB1B A0B A2B GND GND LED6 LED4 LED2 PE7 +5BKLT
J3
GND DB6B DB4B DB2B DB0B A1B A3B
GND DB7B DB5B DB3B DB1B A0B A2B
J2
GND LED7 LED5 LED3 LED1 /RES VCC
GND GND LED6 LED4 LED2 PE7 +5BKLT

Figure D-6. LCD/Keypad Module Pinouts

D.4.1 I/O Address Assignments

The LCD and keypad on the LCD/keypad module are addressed by the /CS strobe as explained in Table D-2.

Table D-2. LCD/Keypad Module Address Assignment

Address	Function
0xE000	Device select base address (/CS)
0xExx0–0xExx7	LCD control
0xExx8	LED enable
0xExx9	Not used
0xExxA	7-key keypad
0xExxB (bits 0–6)	7-LED driver
0xExxB (bit 7)	LCD backlight on/off
0xExxC–ExxF	Not used

D.5 Mounting LCD/Keypad Module on the Prototyping Board

Install the LCD/keypad module on header sockets LCD1JA, LCD1JB, and LCD1JC of the Prototyping Board as shown in Figure D-7. Be careful to align the pins over the headers, and do not bend them as you press down to mate the LCD/keypad module with the Prototyping Board.

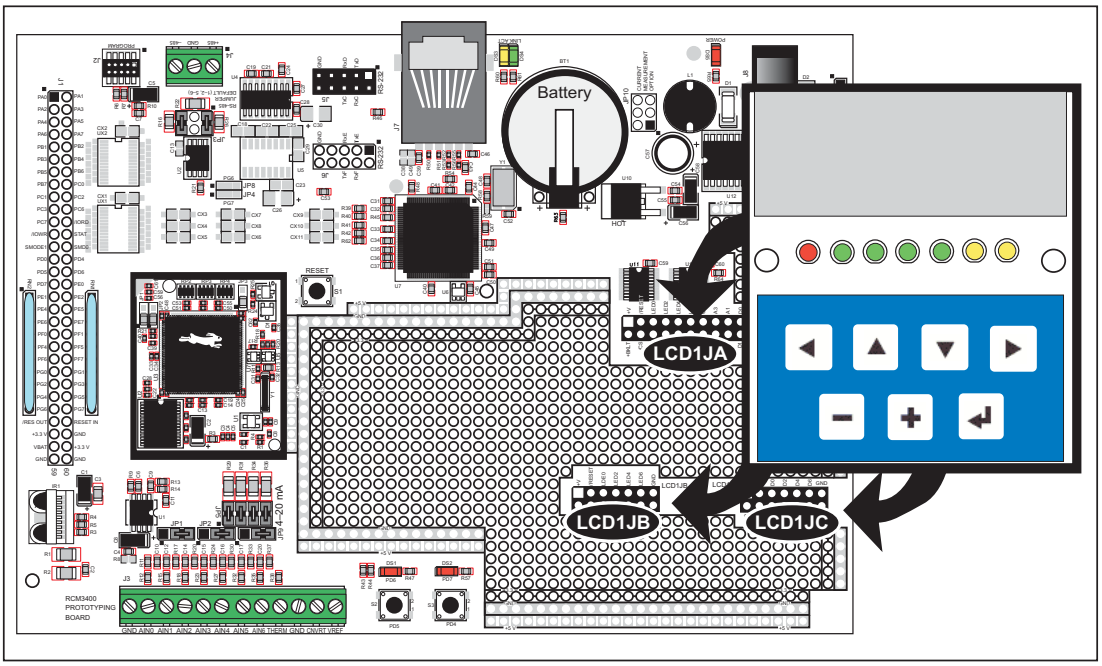


Figure D-7. Install LCD/Keypad Module on Prototyping Board

D.6 Bezel-Mount Installation

This section describes and illustrates how to bezel-mount the LCD/keypad module designed for remote installation. Follow these steps for bezel-mount installation.

1. Cut mounting holes in the mounting panel in accordance with the recommended dimensions in Figure D-8, then use the bezel faceplate to mount the LCD/keypad module onto the panel.

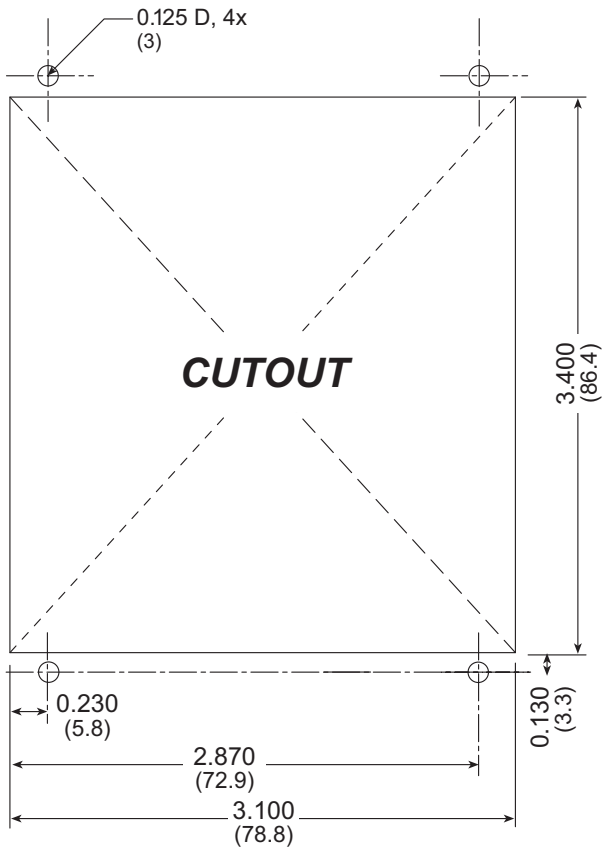


Figure D-8. Recommended Cutout Dimensions

2. Carefully “drop in” the LCD/keypad module with the bezel and gasket attached.

3. Fasten the unit with the four 4-40 screws and washers included with the LCD/keypad module. If your panel is thick, use a 4-40 screw that is approximately 3/16" (5 mm) longer than the thickness of the panel.

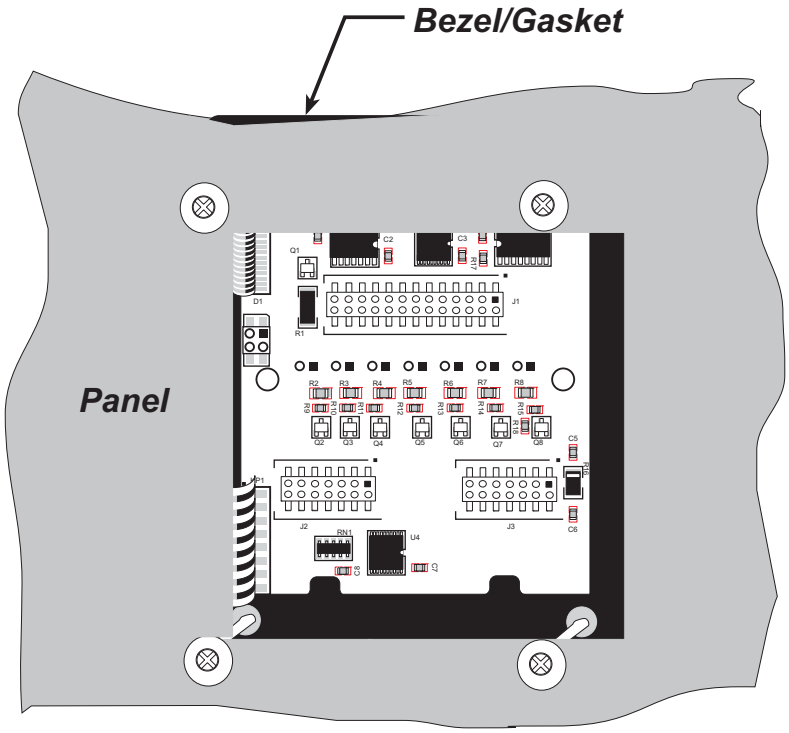


Figure D-9. LCD/Keypad Module Mounted in Panel (rear view)

Carefully tighten the screws until the gasket is compressed and the plastic bezel faceplate is touching the panel.

Do not tighten each screw fully before moving on to the next screw. Apply only one or two turns to each screw in sequence until all are tightened manually as far as they can be so that the gasket is compressed and the plastic bezel faceplate is touching the panel.

D.6.1 Connect the LCD/Keypad Module to Your Prototyping Board

The LCD/keypad module can be located as far as 2 ft. (60 cm) away from the RCM3400 Prototyping Board, and is connected via a ribbon cable as shown in Figure D-10.

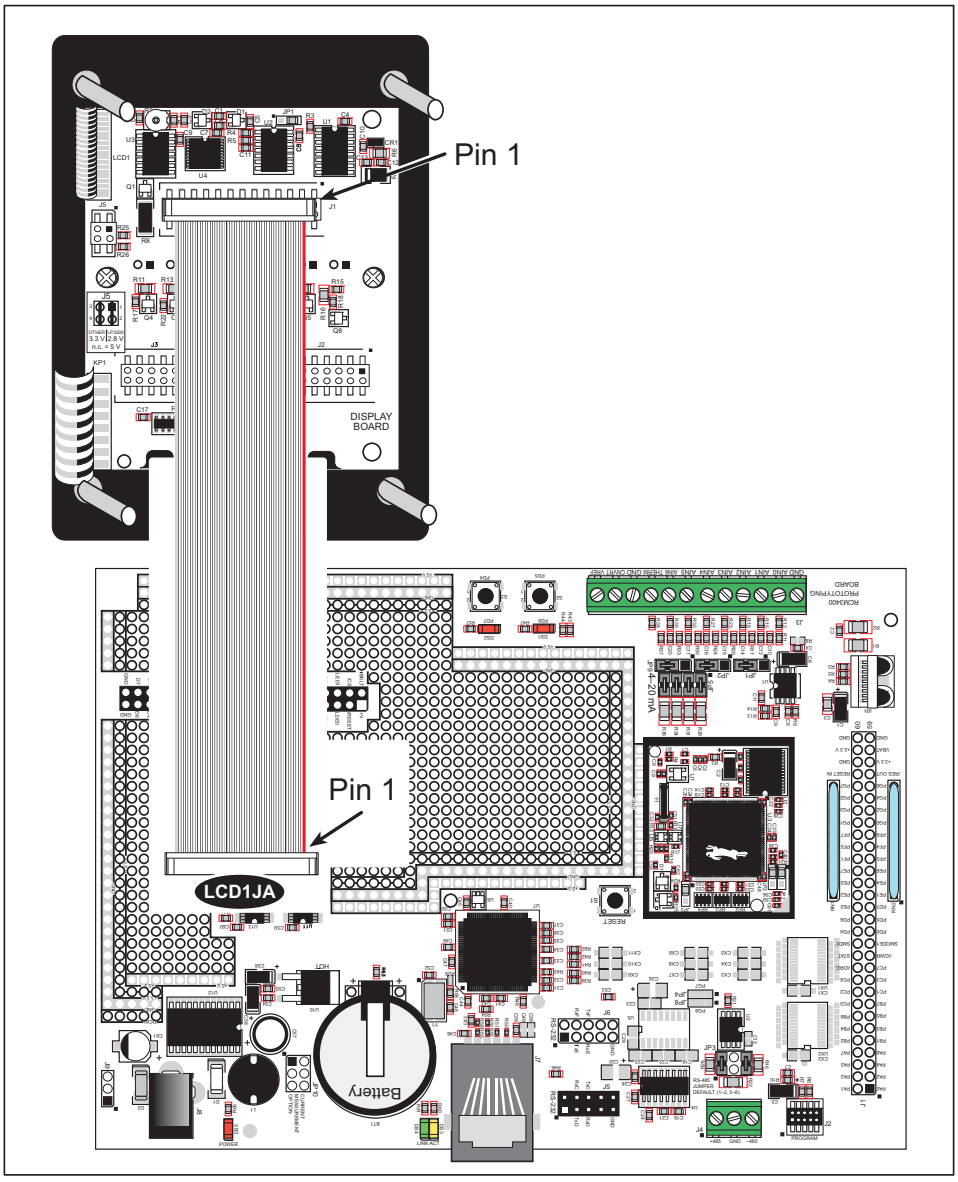


Figure D-10. Connecting LCD/Keypad Module to RCM3400 Prototyping Board

Note the locations and connections relative to pin 1 on both the RCM3400 Prototyping Board and the LCD/keypad module.

Digi offers 2 ft. (60 cm) extension cables. Contact your authorized Digi distributor or a sales representative for more information.

D.7 Sample Programs

Sample programs illustrating the use of the LCD/keypad module with the Prototyping Board are provided in the **SAMPLES\RCM3400\LCD_KEYPAD** directory.

These sample programs use the auxiliary I/O bus on the Rabbit 3000 chip, and so the **#define PORTA_AUX_IO** line is already included in the sample programs.

Each sample program has comments that describe the purpose and function of the program. Follow the instructions at the beginning of the sample program. To run a sample program, open it with the **File** menu (if it is not still open), then compile and run it by pressing **F9**. The RCM3400 must be connected to a PC using the programming cable as described in Chapter 2, "Getting Started.".

Complete information on Dynamic C is provided in the ***Dynamic C User's Manual***.

- **KEYPADTOLED.C**—This program demonstrates the use of the external I/O bus. The program will light up an LED on the LCD/keypad module and will display a message on the LCD when a key press is detected. The DS1 and DS2 LEDs on the Prototyping Board will also light up.
- **LCDKEYFUN.C**—This program demonstrates how to draw primitive features from the graphic library (lines, circles, polygons), and also demonstrates the keypad with the key release option.
- **SWITCHTOLED.C**—This program demonstrates the use of the external I/O bus. The program will light up an LED on the LCD/keypad module and will display a message on the LCD when a switch press is detected. The DS1 and DS2 LEDs on the Prototyping Board will also light up.

Additional sample programs are available in the **SAMPLES\LCD_KEYPAD\122×32_1×7** subdirectory.

D.8 LCD/Keypad Module Function Calls

When mounted on the Prototyping Board, the LCD/keypad module uses the auxiliary I/O bus on the Rabbit 3000 chip. Remember to add the line

```
#define PORTA_AUX_IO
```

to the beginning of any programs using the auxiliary I/O bus.

D.8.1 LCD/Keypad Module Initialization

The function used to initialize the LCD/keypad module can be found in the Dynamic C **LIB\DISPLAYS\LCD122KEY7_LIB** library.

```
void dispInit();
```

Initializes the LCD/keypad module. The keypad is set up using **keypadDef()** or **keyConfig()** after this function call.

RETURN VALUE

None.

D.8.2 LEDs

When power is applied to the LCD/keypad module for the first time, the red LED (DS1) will come on, indicating that power is being applied to the LCD/keypad module. The red LED is turned off when the **brdInit** function executes.

One function is available to control the LEDs, and can be found in the Dynamic C **LIB\DISPLAYS\LCD122KEY7_LIB** library.

```
void displedOut(int led, int value);
```

LED on/off control. This function will only work when the LCD/keypad module is installed on the Prototyping Board.

PARAMETERS

led is the LED to control.

0 = LED DS1
1 = LED DS2
2 = LED DS3
3 = LED DS4
4 = LED DS5
5 = LED DS6
6 = LED DS7

value is the value used to control whether the LED is on or off (0 or 1).

0 = off
1 = on

RETURN VALUE

None.

SEE ALSO

brdInit

D.8.3 LCD Display

The functions used to control the LCD display are contained in the **GRAPHIC.LIB** library located in the Dynamic C **LIB\DISPLAYS\GRAPHIC** library folder. When *x* and *y* coordinates on the display screen are specified, *x* can range from 0 to 121, and *y* can range from 0 to 31. These numbers represent pixels from the top left corner of the display.

void glInit(void);

Initializes the display devices, clears the screen.

RETURN VALUE

None.

SEE ALSO

glDispOnOFF, glBacklight, glSetContrast, glPlotDot, glBlock, glPlotDot, glPlotPolygon, glPlotCircle, glHScroll, glVScroll, glXFontInit, glPrintf, glPutChar, glSetBrushType, glBuffLock, glBuffUnlock, glPlotLine

void glBackLight(int onOff);

Turns the display backlight on or off.

PARAMETER

onOff turns the backlight on or off

1—turn the backlight on
0—turn the backlight off

RETURN VALUE

None.

SEE ALSO

glInit, glDispOnoff, glSetContrast

void glDispOnOff(int onOff);

Sets the LCD screen on or off. Data will not be cleared from the screen.

PARAMETER

onOff turns the LCD screen on or off

1—turn the LCD screen on
0—turn the LCD screen off

RETURN VALUE

None.

SEE ALSO

glInit, glSetContrast, glBackLight

void glSetContrast(unsigned level);

Sets display contrast.

> **NOTE:** This function is not used with the LCD/keypad module since the support circuits are not available on the LCD/keypad module.

void glFillScreen(char pattern);

Fills the LCD display screen with a pattern.

PARAMETER

The screen will be set to all black if **`pattern`** is 0xFF, all white if **`pattern`** is 0x00, and vertical stripes for any other pattern.

RETURN VALUE

None.

SEE ALSO

`glBlock, glBlankScreen, glPlotPolygon, glPlotCircle`

void glBlankScreen(void);

Blanks the LCD display screen (sets LCD display screen to white).

RETURN VALUE

None.

SEE ALSO

`glFillScreen, glBlock, glPlotPolygon, glPlotCircle`

void glFillRegion(int left, int top, int width, int height, char pattern);

Fills a rectangular block in the LCD buffer with the pattern specified. Any portion of the block that is outside the LCD display area will be clipped.

PARAMETERS

`left` is the *x* coordinate of the top left corner of the block.

`top` is the *y* coordinate of the top left corner of the block.

`width` is the width of the block.

`height` is the height of the block.

`pattern` is the bit pattern to display (all black if **`pattern`** is 0xFF, all white if **`pattern`** is 0x00, and vertical stripes for any other pattern).

RETURN VALUE

None.

SEE ALSO

`glFillScreen, glBlankScreen, glBlock, glBlankRegion`

void glFastFillRegion(int left, int top, int width, int height, char pattern);

Fills a rectangular block in the LCD buffer with the pattern specified. The block left and width parameters must be byte-aligned. Any portion of the block that is outside the LCD display area will be clipped.

PARAMETERS

left is the *x* coordinate of the top left corner of the block.

top is the *y* coordinate of the top left corner of the block.

width is the width of the block.

height is the height of the block.

pattern is the bit pattern to display (all black if **pattern** is 0xFF, all white if **pattern** is 0x00, and vertical stripes for any other pattern).

RETURN VALUE

None.

SEE ALSO

glFillScreen, glBlankScreen, glBlock, glBlankRegion

void glBlankRegion(int left, int top, int width, int height);

Clears a region on the LCD display. The block left and width parameters must be byte-aligned. Any portion of the block that is outside the LCD display area will be clipped.

PARAMETERS

left is the *x* coordinate of the top left corner of the block (*x* must be evenly divisible by 8).

top is the *y* coordinate of the top left corner of the block.

width is the width of the block (must be evenly divisible by 8).

height is the height of the block.

RETURN VALUE

None.

SEE ALSO

glFillScreen, glBlankScreen, glBlock

void glBlock(int left, int top, int width, int height);

Draws a rectangular block in the page buffer and on the LCD if the buffer is unlocked. Any portion of the block that is outside the LCD display area will be clipped.

PARAMETERS

left is the *x* coordinate of the top left corner of the block.

top is the *y* coordinate of the top left corner of the block.

width is the width of the block.

height is the height of the block.

RETURN VALUE

None.

SEE ALSO

glFillScreen, glBlankScreen, glPlotPolygon, glPlotCircle

void glPlotVPolygon(int n, int *pFirstCoord);

Plots the outline of a polygon in the LCD page buffer, and on the LCD if the buffer is unlocked. Any portion of the polygon that is outside the LCD display area will be clipped. If fewer than 3 vertices are specified, the function will return without doing anything.

PARAMETERS

n is the number of vertices.

pFirstCoord is a pointer to array of vertex coordinates: **x1,y1, x2,y2, x3,y3, ...**

RETURN VALUE

None.

SEE ALSO

glPlotPolygon, glFillPolygon, glFillVPolygon

void glPlotPolygon(int n, int y1, int x1, int y2, int x2, ...);

Plots the outline of a polygon in the LCD page buffer and on the LCD if the buffer is unlocked. Any portion of the polygon that is outside the LCD display area will be clipped. If fewer than 3 vertices are specified, the function will return without doing anything.

PARAMETERS

n is the number of vertices.

y1 is the *y* coordinate of the first vertex.

x1 is the *x* coordinate of the first vertex.

y2 is the *y* coordinate of the second vertex.

x2 is the *x* coordinate of the second vertex.

... are the coordinates of additional vertices.

RETURN VALUE

None.

SEE ALSO

glPlotVPolygon, glFillPolygon, glFillVPolygon

void glFillVPolygon(int n, int *pFirstCoord);

Fills a polygon in the LCD page buffer and on the LCD screen if the buffer is unlocked. Any portion of the polygon that is outside the LCD display area will be clipped. If fewer than 3 vertices are specified, the function will return without doing anything.

PARAMETERS

n is the number of vertices.

pFirstCoord is a pointer to array of vertex coordinates: **x1,y1, x2,y2, x3,y3, ...**

RETURN VALUE

None.

SEE ALSO

glFillPolygon, glPlotPolygon, glPlotVPolygon

void glFillPolygon(int n, int x1, int y1, int x2, int y2, ...);

Fills a polygon in the LCD page buffer and on the LCD if the buffer is unlocked. Any portion of the polygon that is outside the LCD display area will be clipped. If fewer than 3 vertices are specified, the function will return without doing anything.

PARAMETERS

n is the number of vertices.

x1 is the *x* coordinate of the first vertex.

y1 is the *y* coordinate of the first vertex.

x2 is the *x* coordinate of the second vertex.

y2 is the *y* coordinate of the second vertex.

... are the coordinates of additional vertices.

RETURN VALUE

None.

SEE ALSO

glFillVPolygon, glPlotPolygon, glPlotVPolygon

void glPlotCircle(int xc, int yc, int rad);

Draws the outline of a circle in the LCD page buffer and on the LCD if the buffer is unlocked. Any portion of the circle that is outside the LCD display area will be clipped.

PARAMETERS

xc is the *x* coordinate of the center of the circle.

yc is the *y* coordinate of the center of the circle.

rad is the radius of the center of the circle (in pixels).

RETURN VALUE

None.

SEE ALSO

glFillCircle, glPlotPolygon, glFillPolygon

void glFillCircle(int xc, int yc, int rad);

Draws a filled circle in the LCD page buffer and on the LCD if the buffer is unlocked. Any portion of the circle that is outside the LCD display area will be clipped.

PARAMETERS

xc is the *x* coordinate of the center of the circle.

yc is the *y* coordinate of the center of the circle.

rad is the radius of the center of the circle (in pixels).

RETURN VALUE

None.

SEE ALSO

glPlotCircle, glPlotPolygon, glFillPolygon

void glXFontInit(fontInfo *pInfo, char pixWidth, char pixHeight, unsigned startChar, unsigned endChar, unsigned long xmemBuffer);

Initializes the font descriptor structure, where the font is stored in **xmem**. Each font character's bitmap is column major and byte-aligned.

PARAMETERS

pInfo is a pointer to the font descriptor to be initialized.

pixWidth is the width (in pixels) of each font item.

pixHeight is the height (in pixels) of each font item.

startChar is the value of the first printable character in the font character set.

endChar is the value of the last printable character in the font character set.

xmemBuffer is the **xmem** pointer to a linear array of font bitmaps.

RETURN VALUE

None.

SEE ALSO

glPrinf

unsigned long glFontCharAddr(fontInfo *pInfo, char letter);

Returns the **xmem** address of the character from the specified font set.

PARAMETERS

***pInfo** is the **xmem** address of the bitmap font set.

letter is an ASCII character.

RETURN VALUE

xmem address of bitmap character font, column major and byte-aligned.

SEE ALSO

glPutFont, glPrintf

void glPutFont(int x, int y, fontInfo *pInfo, char code);

Puts an entry from the font table to the page buffer and on the LCD if the buffer is unlocked. Each font character's bitmap is column major and byte-aligned. Any portion of the bitmap character that is outside the LCD display area will be clipped.

PARAMETERS

x is the *x* coordinate (column) of the top left corner of the text.

y is the *y* coordinate (row) of the top left corner of the text.

pInfo is a pointer to the font descriptor.

code is the ASCII character to display.

RETURN VALUE

None.

SEE ALSO

glFontCharAddr, glPrintf

void glSetPfStep(int stepX, int stepY);

Sets the **glPrintf()** printing step direction. The *x* and *y* step directions are independent signed values. The actual step increments depend on the height and width of the font being displayed, which are multiplied by the step values.

PARAMETERS

stepX is the **glPrintf** *x* step value

stepY is the **glPrintf** *y* step value

RETURN VALUE

None.

SEE ALSO

Use **glGetPfStep()** to examine the current *x* and *y* printing step direction.

int glGetPfStep(void);

Gets the current **glPrintf()** printing step direction. Each step direction is independent of the other, and is treated as an 8-bit signed value. The actual step increments depends on the height and width of the font being displayed, which are multiplied by the step values.

RETURN VALUE

The *x* step is returned in the MSB, and the *y* step is returned in the LSB of the integer result.

SEE ALSO

Use **glGetPfStep()** to control the *x* and *y* printing step direction.

void glPutChar(char ch, char *ptr, int *cnt, glPutCharInst *pInst)

Provides an interface between the **STDIO** string-handling functions and the graphic library. The **STDIO** string-formatting function will call this function, one character at a time, until the entire formatted string has been parsed. Any portion of the bitmap character that is outside the LCD display area will be clipped.

PARAMETERS

ch is the character to be displayed on the LCD.

***ptr** is not used, but is a place holder for **STDIO** string functions.

***cnt** is not used, is a place holder for **STDIO** string functions.

pInst is a pointer to the font descriptor.

RETURN VALUE

None.

SEE ALSO

glPrintf, glPutFont, doprnt

void glPrintf(int x, int y, fontInfo *pInfo, char *fmt, ...);

Prints a formatted string (much like **printf**) on the LCD screen. Only the character codes that exist in the font set are printed, all others are skipped. For example, '\b', '\t', '\n' and '\r' (ASCII backspace, tab, new line, and carriage return, respectively) will be printed if they exist in the font set, but will not have any effect as control characters. Any portion of the bitmap character that is outside the LCD display area will be clipped.

PARAMETERS

x is the *x* coordinate (column) of the upper left corner of the text.

y is the *y* coordinate (row) of the upper left corner of the text.

pInfo is a pointer to the font descriptor.

***fmt** is a formatted string.

... are formatted string conversion parameter(s).

EXAMPLE

```
glprintf(0,0, &fi12x16, "Test %d\n", count);
```

RETURN VALUE

None.

SEE ALSO

glXFontInit

void glBuffLock(void);

Increments LCD screen locking counter. Graphic calls are recorded in the LCD memory buffer and are not transferred to the LCD if the counter is non-zero.

> **NOTE:** **`glBuffLock()`** and **`glBuffUnlock()`** can be nested up to a level of 255, but be sure to balance the calls. It is not a requirement to use these procedures, but a set of **`glBuffLock()`** and **`glBuffUnlock()`** bracketing a set of related graphic calls speeds up the rendering significantly.

RETURN VALUE

None.

SEE ALSO

`glBuffUnlock, glSwap`

void glBuffUnlock(void);

Decrements the LCD screen locking counter. The contents of the LCD buffer are transferred to the LCD if the counter goes to zero.

RETURN VALUE

None.

SEE ALSO

`glBuffLock, glSwap`

void glSwap(void);

Checks the LCD screen locking counter. The contents of the LCD buffer are transferred to the LCD if the counter is zero.

RETURN VALUE

None.

SEE ALSO

`glBuffUnlock, glBuffLock, _glSwapData` (located in the library specifically for the LCD that you are using)

void glSetBrushType(int type);

Sets the drawing method (or color) of pixels drawn by subsequent graphic calls.

PARAMETER

`type` value can be one of the following macros.

`PIXBLACK` draws black pixels (turns pixel on).
`PIXWHITE` draws white pixels (turns pixel off).
`PIXXOR` draws old pixel XOR'ed with the new pixel.

RETURN VALUE

None.

SEE ALSO

`glGetBrushType`

int glGetBrushType(void);

Gets the current method (or color) of pixels drawn by subsequent graphic calls.

RETURN VALUE

The current brush type.

SEE ALSO

glSetBrushType

void glXGetBitmap(int x, int y, int bmWidth, int bmHeight, unsigned long xBm);

Gets a bitmap from the LCD page buffer and stores it in **xmem** RAM. This function automatically calls **glXGetFastmap** if the left edge of the bitmap is byte-aligned and the left edge and width are each evenly divisible by 8.

This function call is intended for use only when a graphic engine is used to interface with the LCD/keypad module.

PARAMETERS

x is the *x* coordinate in pixels of the top left corner of the bitmap (*x* must be evenly divisible by 8).

y is the *y* coordinate in pixels of the top left corner of the bitmap.

bmWidth is the width in pixels of the bitmap (must be evenly divisible by 8).

bmHeight is the height in pixels of the bitmap.

xBm is the **xmem** RAM storage address of the bitmap.

RETURN VALUE

None.

void glXGetFastmap(int left, int top, int width, int height, unsigned long xmemptr);

Draws bitmap in the specified space. The data for the bitmap are stored in **xmem**. This function is similar to **glXPutBitmap**, except that it's faster. The bitmap must be byte-aligned. Any portion of a bitmap image or character that is outside the LCD display area will be clipped.

This function call is intended for use only when a graphic engine is used to interface with the LCD/keypad module.

PARAMETERS

left is the *x* coordinate of the top left corner of the bitmap (*x* must be evenly divisible by 8).

top is the *y* coordinate in pixels of the top left corner of the bitmap.

width is the width of the bitmap (must be evenly divisible by 8).

height is the height of the bitmap.

xmemptr is the **xmem** RAM storage address of the bitmap.

RETURN VALUE

None.

SEE ALSO

glXPutBitmap, glPrintf

void glPlotDot(int x, int y);

Draws a single pixel in the LCD buffer, and on the LCD if the buffer is unlocked. If the coordinates are outside the LCD display area, the dot will not be plotted.

PARAMETERS

x is the *x* coordinate of the dot.

y is the *y* coordinate of the dot.

RETURN VALUE

None.

SEE ALSO

glPlotline, glPlotPolygon, glPlotCircle

void glPlotLine(int x0, int y0, int x1, int y1);

Draws a line in the LCD buffer, and on the LCD if the buffer is unlocked. Any portion of the line that is beyond the LCD display area will be clipped.

PARAMETERS

x0 is the *x* coordinate of one endpoint of the line.

y0 is the *y* coordinate of one endpoint of the line.

x1 is the *x* coordinate of the other endpoint of the line.

y1 is the *y* coordinate of the other endpoint of the line.

RETURN VALUE

None.

SEE ALSO

glPlotDot, glPlotPolygon, glPlotCircle

void glLeft1(int left, int top, int cols, int rows);

Scrolls byte-aligned window left one pixel, right column is filled by current pixel type (color).

PARAMETERS

left is the top left corner of bitmap, must be evenly divisible by 8, otherwise truncates.

top is the top left corner of the bitmap.

cols is the number of columns in the window, must be evenly divisible by 8, otherwise truncates.

rows is the number of rows in the window.

RETURN VALUE

None.

SEE ALSO

glHScroll, glRight1

void glRight1(int left, int top, int cols, int rows);

Scrolls byte-aligned window right one pixel, left column is filled by current pixel type (color).

PARAMETERS

left is the top left corner of bitmap, must be evenly divisible by 8, otherwise truncates.

top is the top left corner of the bitmap.

cols is the number of columns in the window, must be evenly divisible by 8, otherwise truncates.

rows is the number of rows in the window.

RETURN VALUE

None.

SEE ALSO

glHScroll, glLeft1

void glUp1(int left, int top, int cols, int rows);

Scrolls byte-aligned window up one pixel, bottom column is filled by current pixel type (color).

PARAMETERS

left is the top left corner of bitmap, must be evenly divisible by 8, otherwise truncates.

top is the top left corner of the bitmap.

cols is the number of columns in the window, must be evenly divisible by 8, otherwise truncates.

rows is the number of rows in the window.

RETURN VALUE

None.

SEE ALSO

glVScroll, glDown1

void glDown1(int left, int top, int cols, int rows);

Scrolls byte-aligned window down one pixel, top column is filled by current pixel type (color).

PARAMETERS

left is the top left corner of bitmap, must be evenly divisible by 8, otherwise truncates.

top is the top left corner of the bitmap.

cols is the number of columns in the window, must be evenly divisible by 8, otherwise truncates.

rows is the number of rows in the window.

RETURN VALUE

None.

SEE ALSO

glVScroll, glUp1

```
void glHScroll(int left, int top, int cols,
   int rows, int nPix);
```

Scrolls right or left, within the defined window by *x* number of pixels. The opposite edge of the scrolled window will be filled in with white pixels. The window must be byte-aligned.

Parameters will be verified for the following:

1. The **`left`** and **`cols`** parameters will be verified that they are evenly divisible by 8. If not, they will be truncated to a value that is a multiple of 8.
2. Parameters will be checked to verify that the scrolling area is valid. The minimum scrolling area is a width of 8 pixels and a height of one row.

PARAMETERS

`left` is the top left corner of bitmap, must be evenly divisible by 8.

`top` is the top left corner of the bitmap.

`cols` is the number of columns in the window, must be evenly divisible by 8.

`rows` is the number of rows in the window.

`nPix` is the number of pixels to scroll within the defined window (a negative value will produce a scroll to the left).

RETURN VALUE

None.

SEE ALSO

`glVScroll`

void glVScroll(int left, int top, int cols, int rows, int nPix);

Scrolls up or down, within the defined window by *x* number of pixels. The opposite edge of the scrolled window will be filled in with white pixels. The window must be byte-aligned.

Parameters will be verified for the following:

1. The **left** and **cols** parameters will be verified that they are evenly divisible by 8. If not, they will be truncated to a value that is a multiple of 8.
2. Parameters will be checked to verify that the scrolling area is valid. The minimum scrolling area is a width of 8 pixels and a height of one row.

PARAMETERS

left is the top left corner of bitmap, must be evenly divisible by 8.

top is the top left corner of the bitmap.

cols is the number of columns in the window, must be evenly divisible by 8.

rows is the number of rows in the window.

nPix is the number of pixels to scroll within the defined window (a negative value will produce a scroll up).

RETURN VALUE

None.

SEE ALSO

glHScroll

void glXPutBitmap(int left, int top, int width, int height, unsigned long bitmap);

Draws bitmap in the specified space. The data for the bitmap are stored in **xmem**. This function calls **glXPutFastmap** automatically if the bitmap is byte-aligned (the left edge and the width are each evenly divisible by 8).

Any portion of a bitmap image or character that is outside the LCD display area will be clipped.

PARAMETERS

left is the top left corner of the bitmap.

top is the top left corner of the bitmap.

width is the width of the bitmap.

height is the height of the bitmap.

bitmap is the address of the bitmap in **xmem**.

RETURN VALUE

None.

SEE ALSO

glXPutFastmap, glPrintf

void glXPutFastmap(int left, int top, int width, int height, unsigned long bitmap);

Draws bitmap in the specified space. The data for the bitmap are stored in **xmem**. This function is like **glXPutBitmap**, except that it is faster. The restriction is that the bitmap must be byte-aligned.

Any portion of a bitmap image or character that is outside the LCD display area will be clipped.

PARAMETERS

left is the top left corner of the bitmap, must be evenly divisible by 8, otherwise truncates.

top is the top left corner of the bitmap.

width is the width of the bitmap, must be evenly divisible by 8, otherwise truncates.

height is the height of the bitmap.

bitmap is the address of the bitmap in **xmem**.

RETURN VALUE

None.

SEE ALSO

glXPutBitmap, glPrintf

int TextWindowFrame(windowFrame *window, fontInfo *pFont, int x, int y, int winWidth, int winHeight)

Defines a text-only display window. This function provides a way to display characters within the text window using only character row and column coordinates. The text window feature provides end-of-line wrapping and clipping after the character in the last column and row is displayed.

NOTE: Execute the **TextWindowFrame** function before other **Text...** functions.

PARAMETERS

window is a pointer to the window frame descriptor.

pFont is a pointer to the font descriptor.

x is the *x* coordinate of the top left corner of the text window frame.

y is the *y* coordinate of the top left corner of the text window frame.

winWidth is the width of the text window frame.

winHeight is the height of the text window frame.

RETURN VALUE

0—window frame was successfully created.
-1—*x* coordinate + width has exceeded the display boundary.
-2—*y* coordinate + height has exceeded the display boundary.
-3—Invalid winHeight and/or winWidth parameter value.

void TextBorderInit(windowFrame *wPtr, int border, char *title);

This function initializes the window frame structure with the border and title information.

NOTE: Execute the **TextWindowFrame** function before using this function.

PARAMETERS

wPtr is a pointer to the window frame descriptor.

border is the border style:

SINGLE_LINE—The function will draw a single-line border around the text window.

DOUBLE_LINE—The function will draw a double-line border around the text window.

title is a pointer to the title information:

If a **NULL** string is detected, then no title is written to the text menu.

If a string is detected, then it will be written center-aligned to the top of the text menu box.

RETURN VALUE

None.

SEE ALSO

TextBorder, TextGotoXY, TextPutChar, TextWindowFrame, TextCursorLocation

void TextBorder(windowFrame *wPtr);

This function displays the border for a given window frame. This function will automatically adjust the text window parameters to accommodate the space taken by the text border. This adjustment will only occur once after the **TextBorderInit** function executes.

NOTE: Execute the **TextWindowFrame** function before using this function.

PARAMETERS

wPtr is a pointer to the window frame descriptor.

RETURN VALUE

None.

SEE ALSO

TextBorderInit, TextGotoXY, TextPutChar, TextWindowFrame, TextCursorLocation

void TextGotoXY(windowFrame *window, int col, int row);

Sets the cursor location to display the next character. The display location is based on the height and width of the character to be displayed.

> **NOTE:** Execute the **TextWindowFrame** function before using this function.

PARAMETERS

window is a pointer to a font descriptor.

col is a character column location.

row is a character row location.

RETURN VALUE

None.

SEE ALSO

TextPutChar, TextPrintf, TextWindowFrame

void TextCursorLocation(windowFrame *window, int *col, int *row);

Gets the current cursor location that was set by a Graphic **Text...** function.

> **NOTE:** Execute the **TextWindowFrame** function before using this function.

PARAMETERS

window is a pointer to a font descriptor.

col is a pointer to cursor column variable.

row is a pointer to cursor row variable.

RETURN VALUE

Lower word = Cursor Row location
Upper word = Cursor Column location

SEE ALSO

TextGotoXY, TextPrintf, TextWindowFrame, TextCursorLocation

void TextPutChar(struct windowFrame *window, char ch);

Displays a character on the display where the cursor is currently pointing. Once a character is displayed, the cursor will be incremented to the next character position. If any portion of a bitmap character is outside the LCD display area, the character will not be displayed.

NOTE: Execute the **TextWindowFrame** function before using this function.

PARAMETERS

***window** is a pointer to a font descriptor.

ch is a character to be displayed on the LCD.

RETURN VALUE

None.

SEE ALSO

TextGotoXY, TextPrintf, TextWindowFrame, TextCursorLocation

void TextPrintf(struct windowFrame *window, char *fmt, ...);

Prints a formatted string (much like **printf**) on the LCD screen. Only printable characters in the font set are printed; escape sequences '\r' and '\n' are also recognized. All other escape sequences will be skipped over; for example, '\b' and \'t' will cause nothing to be displayed.

The text window feature provides end-of-line wrapping and clipping after the character in the last column and row is displayed. The cursor then remains at the end of the string.

NOTE: Execute the **TextWindowFrame** function before using this function.

PARAMETERS

window is a pointer to a font descriptor.

***fmt** is a formatted string.

... are formatted string conversion parameter(s).

EXAMPLE

```
TextPrintf(&TextWindow, "Test %d\n", count);
```

RETURN VALUE

None.

SEE ALSO

TextGotoXY, TextPutChar, TextWindowFrame, TextCursorLocation

int TextMaxChars(windowFrame *wPtr);

This function returns the maximum number of characters that can be displayed within the text window.

NOTE: Execute the **TextWindowFrame** function before using this function.

PARAMETERS

wPtr is a pointer to the window frame descriptor.

RETURN VALUE

The maximum number of characters that can be displayed within the text window.

SEE ALSO

TextGotoXY, TextPrintf, TextWindowFrame, TextCursorLocation

void TextWinClear(windowFrame *wPtr);

This functions clears the entire area within the specified text window.

NOTE: Execute the **TextWindowFrame** function before using this function.

PARAMETERS

wPtr is a pointer to the window frame descriptor.

RETURN VALUE

None.

SEE ALSO

TextGotoXY, TextPrintf, TextWindowFrame, TextCursorLocation

D.8.4 Keypad

The functions used to control the keypad are contained in the Dynamic C **LIB\KEYPADS\KEYPAD7.LIB** library.

```
void keyInit(void);
```

Initializes keypad process

RETURN VALUE

None.

SEE ALSO

brdInit

```
void keyConfig(char cRaw, char cPress,
   char cRelease, char cCntHold, char cSpdLo,
   char cCntLo, char cSpdHi);
```

Assigns each key with key press and release codes, and hold and repeat ticks for auto repeat and debouncing.

PARAMETERS

cRaw is a raw key code index.

1 × 7 keypad matrix with raw key code index assignments (in brackets):

[0]		[1]		[2]		[3]
	[4]		[5]		[6]	

User Keypad Interface

cPress is a key press code

An 8-bit value is returned when a key is pressed.
0 = Unused.

See **keypadDef()** for default press codes.

cRelease is a key release code.

An 8-bit value is returned when a key is pressed.
0 = Unused.

cCntHold is a hold tick, which is approximately one debounce period or 5 µs.

How long to hold before repeating.
0 = No Repeat.

cSpdLo is a low-speed repeat tick, which is approximately one debounce period or 5 µs.

How many times to repeat.
0 = None.

cCntLo is a low-speed hold tick, which is approximately one debounce period or 5 µs.

How long to hold before going to high-speed repeat.
0 = Slow Only.

cSpdHi is a high-speed repeat tick, which is approximately one debounce period or 5 µs.

How many times to repeat after low speed repeat.
0 = None.

RETURN VALUE

None.

SEE ALSO

keyProcess, keyGet, keypadDef

void keyProcess(void);

Scans and processes keypad data for key assignment, debouncing, press and release, and repeat.

NOTE: This function is also able to process an 8 × 8 matrix keypad.

RETURN VALUE

None

SEE ALSO

keyConfig, keyGet, keypadDef

char keyGet(void);

Get next keypress

RETURN VALUE

The next keypress, or 0 if none

SEE ALSO

keyConfig, keyProcess, keypadDef

int keyUnget(char cKey);

Pushes the value of **cKey** to the top of the input queue, which is 16 bytes deep.

PARAMETER

cKey

RETURN VALUE

None.

SEE ALSO

keyGet

void keypadDef();

Configures the physical layout of the keypad with the desired ASCII return key codes.

Keypad physical mapping 1 × 7

0	4	1	5	2	6	3
['L']		['U']		['D']		['R']
	['–']		['+']		['E']	

where

'L' represents Left Scroll
'U' represents Up Scroll
'D' represents Down Scroll
'R' represents Right Scroll
'–' represents Page Down
'+' represents Page Up
'E' represents the ENTER key

Example: Do the following for the above physical vs. ASCII return key codes.

```
keyConfig (  3,'R',0, 0, 0, 0, 0 );
keyConfig (  6,'E',0, 0, 0, 0, 0 );
keyConfig (  2,'D',0, 0, 0, 0, 0 );
keyConfig (  4,'-',0, 0, 0, 0, 0 );
keyConfig (  1,'U',0, 0, 0, 0, 0 );
keyConfig (  5,'+',0, 0, 0, 0, 0 );
keyConfig (  0,'L',0, 0, 0, 0, 0 );
```

Characters are returned upon keypress with no repeat.

RETURN VALUE

None.

SEE ALSO

keyConfig, keyGet, keyProcess

void keyScan(char *pcKeys);

Writes "1" to each row and reads the value. The position of a keypress is indicated by a zero value in a bit position.

PARAMETER

pcKeys is a pointer to the address of the value read.

RETURN VALUE

None.

SEE ALSO

keyConfig, keyGet, keypadDef, keyProcess

APPENDIX E. POWER SUPPLY

Appendix D provides information on the current requirements of the RCM3400, and includes some background on the chip select circuit used in power management.

E.1 Power Supplies

The RCM3400 requires a regulated 2.8 V – 3.45 V DC power source. The RabbitCore design presumes that the voltage regulator is on the user board, and that the power is made available to the RCM3400 board through header J1.

An RCM3400 with no loading at the outputs operating at 29.4 MHz typically draws 97 mA.

E.1.1 Battery-Backup Circuits

The RCM3400 does not have a battery, but there is provision for a customer-supplied battery to back up the data SRAM and keep the internal Rabbit 3000 real-time clock running.

Header J2, shown in Figure E-1, allows access to the external battery. This header makes it possible to connect an external 3 V power supply. This allows the SRAM and the internal Rabbit 3000 real-time clock to retain data with the RCM3400 powered down.

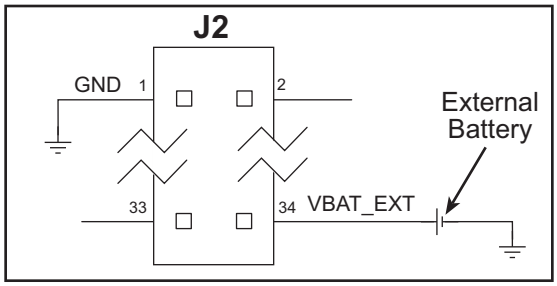


Figure E-1. External Battery Connections at Header J5

A lithium battery with a nominal voltage of 3 V and a minimum capacity of 165 mA·h is recommended. A lithium battery is strongly recommended because of its nearly constant nominal voltage over most of its life.

The drain on the battery by the RCM3400 is typically 7.5 µA when no other power is supplied. If a 165 mA·h battery is used, the battery can last about 2.5 years:

$$\frac{165\ \text{mA}\cdot\text{h}}{7.5\ \mu\text{A}} = 2.5\ \text{years}.$$

The actual life in your application will depend on the current drawn by components not on the RCM3400 and on the storage capacity of the battery. The RCM3400 does not drain the battery while it is powered up normally.

Cycle the main power off/on on the RCM3400 after you install a backup battery for the first time, and whenever you replace the battery. This step will minimize the current drawn by the real-time clock oscillator circuit from the backup battery should the RCM3400 experience a loss of main power.

NOTE: Remember to cycle the main power off/on any time the RCM3400 is removed from the Protoyping Board or motherboard since that is where the backup battery would be located.

E.1.2 Reset Generator

The RCM3400 uses a reset generator to reset the Rabbit 3000 microprocessor when the voltage drops below the voltage necessary for reliable operation. The reset occurs between 2.85 V and 3.00 V, typically 2.93 V. The RCM3400 has a reset output, pin 33 on header J1.

INDEX

A

A/D converter
  calibration 33, 83
  function calls
    anaIn 45
    anaInCalib 46
    anaInConfig 41
    anaInDiff 49
    anaInDriver 43
    anaInEERd 51
    anaInEEWr 53
    anaInmAmps 50
    anaInVolts 48
  inputs
    current measurements ... 82
    differential measurements . 81
    negative voltages 81
    single-ended measurements 80
additional information
  online documentation 5
analog inputs *See* A/D converter
auxiliary I/O bus 26
  software 26, 117

B

battery backup
  battery life 142
  external battery connections . 141
  reset generator 142
board initialization
  function calls 40
    brdInit 40
bus loading 63

C

clock doubler 34
conformal coating 68
connectivity interface kits
  Connector Adpater Board ... 5
  Wi-Fi Add-On Kit 5
Connector Adapter Board 5

D

Development Kits 4
  RCM3400 Development Kit 4
    AC adapter 4
    DC power supply 4
    Getting Started instructions 4
    programming cable 4
digital I/O 20
  I/O buffer sourcing and sinking limits 67
  memory interface 26
  SMODE0 ..... 26, 28
  SMODE1 ..... 26, 28
dimensions
  LCD/keypad module 107
  LCD/keypad template 110
  Prototyping Board 75
  RCM3400 58
Dynamic C 5, 7, 11, 37
  add-on modules 7
    installation 7
  COM port 11
  libraries 39
  sample programs 14
  standard features 38
    debugging 38
  telephone-based technical support 5, 55
  upgrades and patches 55
  USB port settings 11

E

Ethernet cables 93
Ethernet connections 93, 95
  10Base-T 95
  10Base-T Ethernet card 93
  additional resources 105
  direct connection 95
  Ethernet cables 95
  Ethernet hub 93
  IP addresses 95, 97
  MAC addresses 98
  steps 93, 94
exclusion zone 59

F

features 1
  Prototyping Boards 72, 73
flash memory addresses
  user blocks 35

H

hardware connections
  install RCM3400 on Prototyping Board 8
  power supply 10
  programming cable 9
hardware reset 10
headers
  Prototyping Board
    JP3 87

I

I/O address assignments
  LCD/keypad module 111
I/O buffer sourcing and sinking limits 67
IP addresses 97
  how to set in sample programs 102
  how to set PC IP address 103

J

jumper configurations
  Prototyping Board 90
    JP1 (analog inputs reference) 90
    JP10 (current measurement option) 91
    JP2 (analog inputs reference) 90

JP3 (RS-485 bias and termination resistors) 87, 91
JP4 (PG7 RS-232/RS-485 select) 91
JP5 (analog voltage/4–20 mA measurement options) 91
JP6 (PG3 IrDA/RS-232 select) 91
JP7 (PG2 IrDA/RS-232 select) 91
JP8 (PG6 RS-232/RS-485 select) 91
JP9 (analog inputs reference) 91
RCM3400 69
JP1 (flash memory size) 69
JP2 (flash memory bank select) 35, 69
JP3 (SRAM size) 69
jumper locations 69

K

keypad template 110
removing and inserting label . 110

L

LCD/keypad module
bezel-mount installation ..113
dimensions 107
function calls
dispInit 117
displedOut 117
keypad
keyConfig 138
keyGet 139
keyInit 138
keypadDef 140
keyProcess 139
keyScan 140
keyUnget 139
LCD display
glBackLight 118
glBlankRegion 120
glBlankScreen 119
glBlock 121
glBuffLock 127
glBuffUnlock 127
glDispOnOff 118
glDown1 130
glFastFillRegion 120
glFillCircle 123
glFillPolygon 123
glFillRegion 119
glFillScreen 119
glFillVPolygon 122
glFontCharAddr 124
glGetBrushType 128
glGetPfStep 125
glHScroll 131
glInit 118
glLeft1 129
glPlotCircle 123
glPlotDot 129
glPlotLine 129
glPlotPolygon 122
glPlotVPolygon 121
glPrintf 126
glPutChar 126
glPutFont 125
glRight1 130
glSetBrushType 127
glSetContrast 119
glSetPfStep 125
glSwap 127
glUp1 130
glVScroll 132
glXFontInit 124
glXGetBitmap 128
glXGetFastmap 128
glXPutBitmap 132
glXPutFastmap 133
TextBorder 134
TextBorderInit 134
TextCursorLocation .135
TextGotoXY 135
TextMaxChars 137
TextPrintf 136
TextPutChar 136
TextWinClear 137
TextWindowFrame ..133
LEDs 117
header pinout 111
I/O address assignments ..111
keypad template 110
mounting instructions 112
reconfigure keypad 110
remote cable connection ..115
removing and inserting keypad label 110
sample programs 116
specifications 108
versions 107
voltage settings 109

M

MAC addresses 98
mounting instructions
LCD/keypad module 112

P

pinout
LCD/keypad module 111
Prototyping Board 77
Ethernet port 88
RCM3400
alternate configurations . 22
RCM3400 headers 20
power supplies
+3.3 V 141
battery backup 141
Program Mode 29
switching modes 29
programming cable
PROG connector 29
RCM3400 connections 9
programming port 27
Prototyping Board 72
access to RCM3400 analog inputs 73
adding components 79
dimensions 75
Ethernet port 88
handling EMI and noise 88
pinout 88
expansion area 73
features 72, 73
jumper configurations 90
jumper locations 90
mounting RCM3400 8
pinout 77
power supply 76
prototyping area 79
RS-485 network 86
specifications 76
use of Rabbit 3000 signals 78

R

Rabbit 3000
data and clock delays 65
spectrum spreader time delays 65
Rabbit subsystems 21
RCM3400
mounting on Prototyping Board 8
reset 10
RS-485 network
termination and bias resistors 87
Run Mode 29

switching modes 29

S

sample programs 14
A/D converter inputs
AD_CAL_ALL.C ... 17, 83
AD_CAL_CHAN.C 17
AD_CAL_DIFF.C 17
AD_CALDIFF_CH.C ... 83
AD_CALMA_CH.C 17, 83
AD_RDDIFF_CH.C 17, 83
AD_RDMA_CH.C .. 17, 83
AD_RDVOLT_ALL.C 17, 83
AD_SAMPLE.C 17
ANAINCONFIG.C 17
D_CAL_CHAN.C 83
DNLOADCALIB.C 18
THERMISTOR.C ... 18, 82
UPLOADCALIB.C 18
getting to know the RCM3400
CONTROLLED.C 14
FLASHLED1.C 15
FLASHLED2.C 15
IR_DEMO.C 15
TOGGLESWITCH.C 15
how to run TCP/IP sample programs 101, 102
how to set IP address 102
LCD/keypad module 116
KEYBASIC.C 110
KEYPADTOLED.C 116
LCDKEYFUN.C 116
reconfigure keypad 110
SWITCHTOLED.C 116
PONG.C 11
real-time clock
RTC_TEST.C 18
SETRTCKB.C 18
serial communication
FLOWCONTROL.C 15
PARITY.C 16
SIMPLE3WIRE.C 16
SIMPLE485MASTER.C 17
SIMPLE485SLAVE.C .. 17
SIMPLE5WIRE.C 16
SWITCHCHAR.C 16
TCP/IP
BROWSELED.C 104
DISPLAY_MAC.C 98
MBOXDEMO.C 104
PINGLED.C 104
PINGME.C 104
SMTP.C 104
serial communication 27
Prototyping Board
RS-232 85
RS-485 network 86
RS-485 termination and bias resistors 87
serial ports 27
Ethernet port 88
programming port 27
software 5
auxiliary I/O bus 39
I/O drivers 39
libraries 39
KEYPAD7.LIB 138
LCD/keypad module ... 117
PACKET.LIB 39
RCM34xx.LIB 40
RS232.LIB 39
TCP/IP 39
sample programs 14
serial communication drivers 39
TCP/IP drivers 39
upgrading Dynamic C 55
specifications 57
bus loading 63
digital I/O buffer sourcing and sinking limits 67
dimensions 58
electrical, mechanical, and environmental 60
exclusion zone 59
header footprint 62
headers 62
LCD/keypad module
dimensions 107
electrical 108
header footprint 108
mechanical 108
relative pin 1 locations 108
temperature 108
Prototyping Board 76
Rabbit 3000 DC characteristics 66
Rabbit 3000 timing diagram . 64
relative pin 1 locations 62
spectrum spreader 65
settings 34
subsystems
digital inputs and outputs .. 20
switching modes 29

T

TCP/IP primer 95
technical support 12

U

USB/serial port converter
Dynamic C settings 11
user block
function calls
readUserBlock 35
writeUserBlock 35

W

Wi-Fi Add-On Kit 5